

THE AUSTRALIAN AND NEW ZEALAND JOURNAL OF SURGERY

UNDER THE DIRECTION OF THE EDITORIAL COMMITTEE
OF THE ROYAL AUSTRALASIAN COLLEGE OF SURGEONS

SIR HUGH DEVINE, Chairman.

E. D. AHERN (Q.)
ARCHIE J. ASPINALL (N.S.W.)
SIR L. BARNETT (N.Z.)
F. G. BELL (N.Z.)
(Editorial Secretary in New Zealand)
A. E. BROWN (Vic.)
V. M. COPPLESON (N.S.W.)
PROFESSOR H. R. DEW (N.S.W.)
SIR THOMAS DUNHILL (Eng.)
SIR JAMES ELLIOTT (N.Z.)
P. S. FOSTER (N.Z.)
F. A. HADLEY (W.A.)
T. E. VICTOR HURLEY (Vic.)
E. S. J. KING (Vic.)

L. C. E. LINDON (S.A.)
FAY MACLURE (Vic.)
F. A. MAGUIRE (N.S.W.)
SIR HENRY NEWLAND (S.A.)
SIR ALAN NEWTON (Vic.)
H. R. G. POATE (N.S.W.)
BALCOMBE QUICK (Vic.)
SIR CARRICK ROBERTSON (N.Z.)
F. P. SANDES (N.S.W.)
JULIAN SMITH, Junr. (Vic.)
PROFESSOR J. C. WINDEYER (N.S.W.)
D. S. WYLIE (N.Z.)
B. T. ZWAR (Vic.)

MERVYN ARCHDALL, Editor.

I. DOUGLAS MILLER, Secretary to the Editorial Committee.

VOLUME XII—1942-1943

ISSUED QUARTERLY

Single Numbers, 7s. 6d.

Annual Subscription, £1 10s.

SYDNEY

BUTTERWORTH & CO. (AUSTRALIA) LTD.

(Incorporated in England)

6-8 O'Connell Street

Melbourne, Vic.: 430 Bourke Street.
Wellington, N.Z.: 49-51 Ballance Street.
London: Butterworth & Co. (Publishers)
Ltd., Bell Yard, Temple Bar.

Bombay: Butterworth & Co. (India) Ltd.
Toronto: Butterworth & Co. (Canada) Ltd.
Durban: Butterworth & Co. (Africa) Ltd.

LIBRARY
NO. 0747

The Australian and New Zealand Journal of Surgery

JULY, 1942.

TABLE OF CONTENTS.

[The Whole of the Literary Matter in THE AUSTRALIAN AND NEW ZEALAND JOURNAL OF SURGERY is Copyright.]

ORIGINAL ARTICLES—

	PAGE
CARBUNCLE OF THE KIDNEY: A REPORT OF THREE CASES AND A REVIEW OF THE LITERATURE	<i>R. N. Howard</i> 3
EXPERIENCES IN THORACIC SURGERY IN A BASE HOSPITAL IN THE MIDDLE EAST	<i>E. S. J. King</i> 22
THE TREATMENT OF BURNS	<i>W. A. Hailes</i> 30
THE LOCAL USE OF SULPHONAMIDE COMPOUNDS	<i>T. E. Wilson</i> 34
INFECTIVE COMPLICATIONS OF HEAD BATTLE CASUALTIES	<i>D. Miller</i> 53
EXCISION AND PRIMARY SUTURE OF WOUNDS IN WAR SURGERY	<i>W. A. Hailes</i> 64

SURGICAL TECHNIQUE—

OPERATION FOR HEMORRHOIDS	<i>D. Robb</i> 68
---------------------------------	-------------------

CASE REPORTS—

CASES OF LUNG INJURY FOLLOWING EXPOSURE TO BLAST AND NITROUS FUMES	<i>F. J. Booth</i> 72
NOTES ON SOME CASES OF MULTIPLE INJURIES RESULTING FROM BOMB EXPLOSION	<i>L. G. Travers</i> 74

SURGERY IN OTHER COUNTRIES—

INTRACRANIAL VASCULAR TUMOURS, WITH REFERENCE TO A DIAGNOSTIC PROCEDURE	77
THE UTERUS AS A CONTENT OF INGUINAL HERNIA IN MEN	78
TUBERCULOUS EPIDIDYMITIS	79
SPONTANEOUS HEALING OF OSTEOCHONDritis DISSECANS IN THE KNEE JOINT	80
LATE RESULTS OF TRANSVERSE SUTURE OF THE DIVIDED URETER	81

REVIEW—

CLINICAL ROENTGENOLOGY OF PREGNANCY	82
---	----

PROCEEDINGS OF THE ROYAL AUSTRALASIAN COLLEGE OF SURGEONS—

THE HYDATID REGISTRY	83
ANNUAL REPORT OF THE COUNCIL	84
COUNCIL MEETING	88

Editorial Notices.

ALL articles submitted for publication in this journal must be typewritten and double or treble spacing should be used. Each article should conclude with a brief summary and statement of conclusions. Authors are requested to avoid the use of abbreviations and not to underline either words or phrases.

Authors are requested to submit two typescript copies of all articles.

References to articles and books should be carefully checked. In a reference the following information should be given without any abbreviation: initials of author, surname of author, full title of article, name of journal, volume, full date (month, day and year), number of the first page of the article. If a reference is made to an abstract of a paper, the name of the original journal, together with that of the journal in which the abstract has appeared, should be given, with full date in each instance.

When illustrations are required, good photographic prints on glossy gaslight paper should be submitted. Line drawings, charts, graphs and so forth should be drawn on thick white paper in indian ink. Authors who are not accustomed to prepare drawings of this kind, are invited to seek the advice of the Editor if they are in any doubt as to the correct procedure. Skiagrams can be reproduced satisfactorily only if good prints or negatives are available.

Editorial communications should be addressed to the Chairman of the Editorial Committee, 57 Collins Street, Melbourne, or to any member of the Editorial Committee. It is understood that original articles forwarded for publication are offered to THE AUSTRALIAN AND NEW ZEALAND JOURNAL OF SURGERY solely, unless the contrary be stated.

Reprints can be supplied at cost price; the minimum number is fifty copies. Orders for reprints must be given when the proof is returned.

Exchange journals should be addressed to the Honorary Librarian, Royal Australasian College of Surgeons, Spring Street, Melbourne, C.1, Victoria, Australia.

Business communications and remittances should be addressed to Butterworth and Co. (Australia) Ltd., 6-8 O'Connell Street, Sydney.

The announcements appearing in this journal contribute largely towards the maintenance of the high standard of the publication. It is, therefore, requested that, wherever possible, readers will support the business houses whose advertisements appear in the journal and that, when placing their orders, they will mention THE AUSTRALIAN AND NEW ZEALAND JOURNAL OF SURGERY.

THE AUSTRALIAN AND NEW ZEALAND JOURNAL OF SURGERY

Registered at the General Post Office, Melbourne, for transmission by post as a periodical.

VOL. XII.

JULY, 1942.

No. 1.

CARBUNCLE OF THE KIDNEY: A REPORT OF THREE CASES AND A REVIEW OF THE LITERATURE.¹

By RUSSELL N. HOWARD,

Major, Australian Army Medical Corps; Honorary Surgeon to Out-Patients, Children's Hospital, Melbourne; Associate Surgical Assistant, Alfred Hospital, Melbourne.

THE following three cases of carbuncle of the kidney were encountered by me within a few months of each other. Having studied the subject to the extent here indicated, I intended, if possible, to put the principles enunciated in these pages into operation and then to report a larger series. During the last four years, however, I have met with no case of true renal carbuncle and am loath to wait indefinitely before committing to print what I hope may be some helpful observations on the question of the treatment of this condition.

CASE REPORTS.

Case I.

D.S., a female, aged six years, was admitted to Saint James's Hospital, Balham, London, on January 24, 1936.

She had been quite well until twenty-four hours previously, when she developed pain in the abdomen, had a severe attack of shivering and vomited. The pain was of diffuse right-sided distribution and persisted until her admission to hospital. No other symptoms, except those usually associated with a febrile illness, were complained of. On examination the patient's temperature was found to be 101.6° F., and the pulse and respiration rates 136 and 26 per minute respectively. Tenderness was present diffusely on the right side of the abdomen and more markedly in the right costo-muscular angle.

The child became very ill, running a remittent temperature which rose to 103° F. in the evening. A week after admission the pain moved to the region of the left loin, and slight tenderness developed in the left costo-muscular angle; the right loin was still tender. No mass was felt at this stage, but may have been concealed owing to the fretful irritability manifested on attempts at examination. On February 2, 1936, tenderness was elicited in both loins, and a mass was thought to be present in the left. The urine contained a few pus cells, and on culture grew *Staphylococcus aureus*. The patient was now desperately ill and apparently grossly anæmic.

On February 12, 1936, under ether anaesthesia induced by the open method, the abdomen was palpated and the left kidney was found to be grossly enlarged. The right kidney was also enlarged, but to a lesser degree. A lumbar incision was made and the left kidney exposed. It appeared almost three times normal size. About one ounce of pus (afterwards proved to contain *Staphylococcus aureus*) was evacuated from a small perinephric abscess situated on the anterior aspect of the upper pole of the kidney. Projecting anteriorly from the kidney in this region, a localized mass was felt, but was not completely visualized. A drainage tube was put down to the abscess and the wound was closed.

¹ Accepted for publication on February 21, 1941.

Following the operation the temperature fell to normal by lysis over three days and thereafter showed no abnormality. The patient's grave condition was ameliorated almost immediately. Very little discharge occurred from the drainage tube, and it was removed on the fifth post-operative day. Aided by a blood transfusion of ten ounces and administration of iron by mouth, the general health rapidly improved, and ten days after operation the wound had ceased to discharge.

On March 10, 1936, neither kidney was palpable, and the wound had healed completely. On this date an excretion pyelogram showed a right kidney of normal appearance, but the upper pole of the left kidney was poorly defined and the upper calyces were not delineated. The patient was discharged from hospital on March 13, 1936 (one month after operation), apparently well. Two months later she appeared to be still in perfect health. No history of a possible septic focus was obtainable.

This patient, I consider, had a carbuncle of the upper pole of the left kidney. There is no doubt that a staphylococcal lesion was present in the right kidney also (the early symptoms and signs were entirely right-sided and the right kidney was felt to be considerably enlarged at the time of operation). The condition of multiple cortical abscesses can be excluded by the paucity of urinary findings and the probability is that the condition was a carbuncle which subsided spontaneously.

Case II.

E.K., a male, aged sixteen years, was admitted to Saint James's Hospital, Balham, London, on June 12, 1936.

About a month earlier the patient had a single small boil on the face, which subsided in four days. Six days before his admission to hospital he developed a slight pain in the left loin and felt "out of sorts", which condition persisted until his admission. Examination then revealed a temperature of 101° F., a pulse rate of 98 and a respiration rate of 24 per minute. Tenderness was present in the left costo-muscular angle.

For the next ten days he ran an evening temperature of 102° F., while nothing further in the way of physical signs developed. The urine was microscopically normal; no culture was obtained on incubation and an X-ray examination of the renal tract revealed no abnormality. Cystoscopy was performed and the bladder was found to be normal. The temperature then subsided by slow lysis and on June 28, 1936, became normal. Occasional pain in the left loin was still experienced and tenderness was still present in this region. On July 3, 1936, an excretion pyelogram revealed an apparently normal right urinary tract, while the left kidney showed gross distortion of the upper calyx, with poor delineation of the upper pole. A renal carbuncle was diagnosed and, although the patient was by this time symptom-free, nephrectomy was thought advisable.

On July 6, 1936, under ether anaesthesia, nephrectomy was performed by the loin route. The kidney was found very adherent anteriorly over the upper pole, but otherwise no difficulty was encountered.

There was present in the upper pole a mass about the size of a walnut, rather irregular in shape, deforming the upper calyx and reaching the surface anteriorly. Microscopic examination showed this mass to consist of degenerate renal parenchyma almost completely replaced by young fibrous tissue with occasional small aggregations of leucocytes (polymorphonuclear cells and lymphocytes).

Convalescence was uneventful and the patient was discharged from hospital on July 26, 1936.

There seems no doubt that this was a renal carbuncle, which had almost completed the process of spontaneous healing and that this end would have been accomplished had the kidney not been removed. Operation was undertaken owing to ignorance of the possibility of such a termination and as far as can be judged would have been better withheld.

Case III.

M.R., a female, aged ten years, was admitted to Saint James's Hospital, Balham, London, on April 8, 1936.

Fourteen days previously she had a rigor and had complained of pain in the right loin. The pain, which was constantly present, aching in character and of considerable severity, had persisted until her admission to hospital.

Her temperature was 103° F., her pulse rate 136 and respiratory rate 28 per minute. She had considerable tenderness and rigidity in the right loin—especially in

the right costo-muscular angle—and in the right hypochondrium. The breath sounds were diminished in intensity at the right lung base.

For the next five days she ran a remittent temperature which rose to 103.5° F. in the evening. The urine was normal on examination and the leucocyte count was 18,000 per cubic millimetre. On the sixth day after her admission to hospital oedema on firm pressure was present in the right loin, and operation was determined upon.

On April 14, 1936, under ether anaesthesia, the right loin was explored and a perinephric abscess containing about four ounces of pus (later shown to contain *Staphylococcus aureus*) was evacuated. The adjacent kidney was grossly enlarged and a tumour presented from the posterior surface of its lower pole. Nephrectomy was performed and the wound was closed with drainage. Section of the kidney showed the tumour to be a necrotic mass of tissue localized to the lower pole, not obviously encapsulated and presenting several small abscesses throughout its substance. It occupied most of the lower half of the kidney, both cortex and medulla, and reached the renal surface posteriorly.

The patient was very ill for the next six days, but then settled down to an uninterrupted convalescence. The drainage tube was removed on the eighth post-operative day and discharge ceased on the twentieth. The patient was dismissed from hospital on May 15, 1936 (approximately a month after operation). No history of a possible causal lesion was obtainable.

This case presents a characteristic history of renal carbuncle of the acute type. The primary nephrectomy performed was probably the correct treatment.

REVIEW OF THE LITERATURE AND DISCUSSION.

The condition known as carbuncle of the kidney was first described and given this name by J. Israel in 1891. Since then a considerable number of cases have been reported.

This paper is based on the study of three personal cases and details of a further eighty-one collected from the literature—eighty-four cases in all. Discussion has often centred about the name "carbuncle of the kidney", mainly maintaining that, as a carbuncle is by definition a disease of skin and subcutaneous tissues, the term is not applicable to the kidney. This view is puristically correct, but the term is aptly descriptive and has obtained such a firm hold on medical imagination that it has undoubtedly come to stay.

Much confusion has arisen owing to failure of many writers to differentiate between carbuncle and other types of staphylococcal renal lesion. In the following pages a renal carbuncle is considered as being "a localized necrotic area of renal parenchyma presenting multiple foci of suppuration". This definition has the advantage of being concise and conforms in essentials with the ideas of most other authors. With it as criterion, many cases reported as examples of the disease must be excluded, either because the recorded facts are too meagre to permit of classification or because they indicate that the case would be more correctly placed in the category of some allied condition.

Pathology.

At the outset it is advisable to indicate that renal carbuncle, although generally susceptible of accurate pathological diagnosis, may on occasion merge into manifestations similar in certain respects, but not conforming to the above requirements—a fact which readily explains some of the confusion in case reports.

Morbid Anatomy.

Renal carbuncle is usually a solitary lesion in the renal tract, but may be associated with a second carbuncle or unilocular abscess (single or multiple) in either the same or opposite kidney.^{(1) (2) (6) (7) (24) (35) (45) (52) (53) (54) (61)} Lesions vary in size from that of a hazel nut to one which involves the whole kidney. There is no doubt that many of the latter are really multicentric lesions with an area of necrosis about each centre, leaving a varying amount of

normal intervening tissue. Renal carbuncles fall into one of three pathological groups: acute, subacute and chronic.

An acute carbuncle presents for examination a central area of necrotic renal tissue. Throughout this region are scattered areas of suppuration of varying size, and traversing it can be felt firmer strands of fibrous tissue which pass to the periphery of the lesion. There may or may not be a peripheral cleavage plane along which the carbuncle can be enucleated from the renal substance. The lesion almost invariably presents upon the surface of the kidney—more frequently anteriorly than posteriorly—and here it may give rise to a perinephric abscess or become adherent to the perirenal fat and adjacent structures. In the other direction it may approach the calyces, deforming them if large enough, and rarely may discharge into the renal pelvis. It is generally situated towards one or other pole of the kidney, usually the upper, and may cause an enlargement of the organ to two or three times its normal size. The remainder of the kidney appears normal.

In the subacute type the softened necrotic material has largely disappeared and the carbuncle is virtually a multilocular abscess, the loculi varying in size and being separated from each other by firm strands of fibrous tissue running peripherally to a fibrous wall, which gradually merges into the normal renal tissue; there is no plane of cleavage at this stage. The perirenal fat is sclerotic and densely adherent to the kidney. A perinephric abscess may be present.

The chronic type represents a final stage in the cicatrization process. The affected area is a fibrous mass, usually enclosing several abscess cavities. The perirenal fat is transformed into fibrous tissue, often exhibiting pockets of pus. The whole mass is densely adherent to surrounding structures—diaphragm, duodenum, inferior vena cava, colon *et cetera*.

Microscopic Pathology.

Commencing at an area where suppuration is present and passing peripherally, one finds first the microscopic appearance of pus. In the two specimens which I have been able to examine, these purulent areas are small in size and rapidly give place to a zone in which predominates young fibrous tissue infiltrated with polymorphonuclear leucocytes and showing remnants of degenerate renal tubules and glomeruli. This zone in turn gives place to a region in which degenerate renal elements are readily distinguishable, tubules and glomeruli being separated by cellular fibroblastic areas showing leucocytic infiltration. Special staining shows clumps of staphylococci in this zone—mainly in the glomeruli. If this collection of zones borders on a similar collection (that is, if it is towards the centre of the carbuncle) one will note the microscopic changes in the reverse order as one proceeds further peripherally. If, on the other hand, one is now inspecting the boundary of the involved area, a zone of intact renal tissue showing marked vascular reaction is extremely prominent.

Complications.

Complications are, in reality, the results of spread of infection. If perinephric abscess can be regarded as a complication, it is by far the most frequent, being present in 55% of the present series—this agreeing with the usual figure given by other authors. Prostatic abscess occurred in 8% of cases.^{(2) (3) (5) (49) (52) (55)} Other complications are rare and include peritonitis (pre-operative or post-operative),^{(1) (37) (53) (59)} post-operative urinary fistula,^{(2) (3) (5) (60)} pericarditis,^{(17) (26)} empyema,^{(49) (52)} pulmonary abscess,^{(26) (52)} osteomyelitis,⁽⁴⁹⁾ cerebral abscess⁽³³⁾ and thrombosis of inferior vena cava.⁽⁵⁸⁾

An acute pyæmia very rarely develops during the course of a renal carbuncle, but a carbuncle may complicate an acute pyæmia.

Ætiology.

The infecting organism is almost invariably the *Staphylococcus aureus*, but Campbell⁽¹⁵⁾ and Joyce⁽³³⁾ report cases in which the *Staphylococcus albus* was responsible. This is quite in accord with the suggested pathogenesis (*vide infra*), and in this connexion Boyd⁽⁸⁾ states that the *Staphylococcus albus*, although generally a harmless skin saprophyte, "may on occasion produce a fatal septicæmia", and further that "the colour-producing power of a given strain of staphylococcus may vary widely". This may account for the occasional instances in which *Staphylococcus albus* is cultured from the urine of a patient, pus from whose kidney grows *Staphylococcus aureus*.⁽¹⁵⁾ Other organisms which have been obtained in pure culture from lesions, apparently renal carbuncles, are *Bacillus coli communis*⁽⁹⁾ and hæmolytic streptococcus;⁽⁴⁸⁾ such cases are extremely rare. In this series *Staphylococcus aureus* was responsible for 92% of cases which were investigated bacteriologically, *Staphylococcus albus* for 4%, *Bacillus coli communis* and streptococcus for 2% each. I have been unable to obtain particulars of the case of Jaffé (mentioned by Cibert and Klajman⁽¹⁷⁾), in which the infecting organism was stated to be the gonococcus.

The origin of these bacteria is usually some cutaneous lesion, such as a boil or carbuncle. Other possible primary foci are axillary abscess,^{(2) (3) (55) (60)} otitis media and mastoiditis,^{(4) (33)} dental abscess,^{(10) (52)} whitlow,^{(21) (51)} antral infection^{(33) (37)} and throat infection.⁽⁹⁾ A primary focus was recorded as being present in only 55% of the present series, despite the fact that other writers consider that it should be traceable in a higher percentage (Brady, 83%⁽⁹⁾). It must be emphasized that this primary infection is frequently insignificant and may have apparently completely subsided before the first feature referable to a renal lesion appears. In connexion with that group of cases in which no primary lesion can be traced, the work of Williams and Timmins⁽⁶⁶⁾ suggests that a subclinical naso-pharyngeal staphylococcal infection may be the cause. This work was carried out with reference to acute osteomyelitis in childhood, a condition analogous in many respects.

Since superficial staphylococcal infections are common and resultant renal lesions are rare (Barney⁽⁴⁾ collected two hundred successive cases of carbuncle without evidence of renal involvement), it would appear that some predisposing cause or causes are active and, further, that they should be essentially unilateral in effect, since bilateral cases are unusual. Age is recorded in eighty of the cases here studied; the youngest patient was eight weeks⁽¹⁵⁾ and the oldest fifty-eight years⁽²⁰⁾ of age, whilst sixty cases (75%) occurred in patients between the ages of ten and forty years. The percentage occurrence in males was 58; this figure compares with those of Cibert and Klajman (62%),⁽¹⁷⁾ Graves and Parkins (62%),⁽²⁶⁾ O'Connor (70%)⁽⁵¹⁾ and Brady (72%).⁽⁹⁾ It must be noted that in these series there is a number of cases common to all. Further, as it is later pointed out that the ætiology of all metastatic staphylococcal renal lesions (of which carbuncle is only one) is essentially similar, statistics obtained from groups of cases including all such lesions should be true, to a certain extent, for renal carbuncle alone. Such groups of cases are reported by Aschner,⁽¹⁾ Barney,⁽⁴⁾ Beer^{(6) (7)} and Nesbit,⁽⁵⁰⁾ and the percentages of males in these series are, respectively, 75, 70, 72 and 63. There thus seems to be no doubt that renal carbuncle is more common in the male sex in about the proportion of three to two.

In regard to the side of the lesion, forty-two (51%) were right-sided, thirty-one (38%) left-sided and nine (11%) bilateral. In two cases the side was not recorded.

The incidence in other reported series is as shown in Table I.

TABLE I.
Side Incidence.

Author.	Right.	Left.	Bilateral.	Number of Cases.
Aschner	43%	55%	2%	61
Barney	58%	33%	9%	121
Brady	57%	43%	0%	67
Nesbit	65%	25%	10%	48
O'Connor	55%	42%	3%	76

In these series, as mentioned before, Aschner,⁽¹⁾ Barney⁽⁴⁾ and Nesbit⁽⁵⁰⁾ have included all types of metastatic staphylococcal renal lesion. The right kidney thus appears to be the more favourable for the development of staphylococcal infections in general and carbuncle in particular.

The significance of these figures with regard to age, sex and side is difficult to understand. It has been thought to indicate that trauma plays a part in the aetiology, the condition occurring at an age period when injury is common, largely in the sex more exposed to accident, and predominantly in that kidney which is the less well protected anatomically. If this suggestion is correct, one finds it hard to understand the comparative immunity in the first decade—a time when staphylococcal osteomyelitis is most common. There are cases which appear to have a definite relation to local trauma. The first carbuncle of the kidney to be described⁽³⁰⁾ had an onset immediately following severe local trauma in a man suffering from carbuncle of the neck; in this case the renal lesion appeared on the injured side. Other cases showing a somewhat similar sequence of events have been reported,^{(58) (62) (63)} but form a small percentage of the total.

Bearing on this question is the experimental work of Brewer,^{(10) (11)} who exposed and traumatized the right kidney of sixteen rabbits and then injected bacterial emulsions intravenously; eight developed renal lesions limited to the right kidney, whilst in three the left kidney was also involved; five were unaffected. A similar series of experiments was performed by the same worker; in these the right kidney was exposed and its blood supply was attenuated by interference with the renal vessels; intravenous injection of *Bacillus coli communis* emulsions gave lesions of the injured organ only. The influence of trauma as well as ischaemia here is obvious, though not commented on by Brewer. This work loses its point somewhat when one realizes the susceptibility of rabbits to infection and the ease with which other investigators (Garrod as reported by Ball^{(2) (3)} and Helmholtz as reported by Cabot^{(13) (14)}) have been able to induce renal lesions without the aid of local trauma.

In short, the case for trauma remains unproven, and in the human being it appears to be no more than a rare factor in the aetiology of renal carbuncle.

As both kidneys are exposed to the same blood stream infection, since bilateral gross renal affection is unusual and since trauma seems an aetiological agent only rarely to be invoked, one must postulate some factor

causing a local lowering of resistance in the affected kidney. The nature of this factor (or factors) seems to be quite unknown. Two cases of renal carbuncle occurring in patients, also the subjects of stone in the ipsilateral ureter, have been recorded.^{(49) (60)} It seems possible that the unknown factor may prove to be increased intrarenal tension, due to anomalies of ureteric action.

The route of transference of organisms from primary focus to kidney is undoubtedly the blood stream—that is, there is at least a transient bacteriæmia. Cultures have been obtained from the blood on a sufficient number of occasions^{(1) (6) (48) (49) (52)} to confirm this as being the mode of infection. Further, the disease in many respects appears to be analogous to hæmatogenous osteomyelitis, in which this route of infection is well proven.

Pathogenesis.

A discussion of the pathogenesis of renal carbuncle involves also a reference to that of other hæmatogenous coccal infections of the kidney. For the sake of clarity such infections will now be tabulated:

1. Carbuncle of the kidney.
2. Solitary unilocular abscess.
3. Multiple cortical abscesses.
4. Perinephric abscess ("idiopathic").

All these conditions have a primary focus and route of transference of infection as postulated for renal carbuncle. The type of disease produced will depend upon the reaction excited in the kidney.

The primary lesion is undoubtedly an arterial or capillary embolus. The renal circulation is so arranged that the renal artery divides to a series of ventral and dorsal branches. Each branch is practically an end artery—that is, anastomosis is very slight. These branches give rise to the interlobar arteries and these, when they reach the zone between cortex and medulla, evolve the arciform arteries, which occupy this intermediate zone and distribute interlobular vessels to the cortex. From the interlobular vessels arise afferent arteries to the glomeruli and blood, having passed through the glomerular capillaries, leaves by efferent arteries from which arise *arteriola recti*, destined to supply the medulla. Thus all blood passing to the kidney proceeds first through the glomerular capillary system in the cortex, and that destined for the medulla reaches it only after this route has been traversed.^{(28) (34) (43)} Consequently, if embolism is to occur, one would expect the emboli to lodge in the cortex (unless they are of sufficiently large dimensions to occlude an interlobar vessel) and this is the area in which the lesions above enumerated actually appear. The almost universal occurrence of staphylococci as the causal organisms is again in accord with the embolic theory, their well-known clumping propensities^{(8) (12) (57)} lending themselves to embolus formation. As further proof, Vermooten⁽⁶⁴⁾ has actually demonstrated microscopically and reproduced an excellent photograph of a staphylococcal embolus of a glomerulus.

Following this embolism an infarct forms, the fate of which will depend on its size, its situation relative to the kidney capsule and the reaction excited by it in the surrounding renal tissue. Staphylococcal infection tends to spread by progressive venous thrombosis and the organisms produce a powerful necrotizing exotoxin. The combination of these actions in a subject with relatively low resistance would produce a large necrotic area before localization would occur. In such an individual a strong polymorphonuclear leucocytic reaction would be unlikely, and a few scattered areas of suppuration in the necrotic area complete the picture of a classical "carbuncle of the

kidney". Fibrous tissue elements in this area may persist and even proliferate, their resistance to bacterial toxins being widely recognized as greater than that of the more delicate parenchymatous cells. These elements provide the carbuncle with its fibrous tissue septa, and a similar reaction at the periphery of the affected area forms its "capsule". The histology of the lesion supports this theory, the tissues of the carbuncle showing degenerated renal epithelium, probably devitalized by a combination of ischemia and toxæmia.⁽¹⁷⁾ It has been suggested that a renal carbuncle is formed by multiple emboli. This, however, seems to me to be unlikely as a universal explanation, for the following reasons: first, it provides no explanation for the multiple emboli lodging in one small area and leaving the rest of the kidney unaffected; secondly, the well-defined and regular shape of the "capsule" in many cases suggests a spread from one central point; thirdly, a true carbuncle—that in the skin and subcutaneous tissues—would appear to start as one focus and increase in size by peripheral extension. It is probable that many so-called carbuncles involving the whole or almost the whole of a kidney may be caused by multiple emboli. It should be noticed, however, that a single embolus can theoretically give rise to a carbuncle of this size simply by the process of progressive thrombosis and dissemination of necrotizing toxin.

In a subject whose tissues have greater powers of resisting the infection, spread from the primary embolus will be checked more rapidly and leucocytic activity probably be greater. Liquefaction of the necrotic area will occur and a unilocal abscess of variable size result.

Multiple bacterial emboli in such a person will produce the "multiple cortical abscesses" picture.

A solitary small lesion immediately beneath the renal capsule may rapidly penetrate it, leaving no very obvious trace of its existence, and produce the so-called "idiopathic" perinephric abscess.

Now, a carbuncle and an abscess may coexist in the one kidney or occur in opposite kidneys in the same patient.^{(17) (35) (40) (54)} One suggests that these differing lesions may be initiated at differing phases of resistance, the initiation of the carbuncle being at a less resistant phase.

In connexion with the pathogenesis a recent article by Semple⁽⁵⁷⁾ is of interest. He finds that in human beings dying of peripheral staphylococcal infection (for example, osteomyelitis) the kidneys show dilatation of the intertubular capillaries of the cortex and that in these capillaries staphylococcal emboli can be seen (even though there is no macroscopic renal lesion). He suggests that such dilatation, by slowing of the blood stream, acts as a predisposing agent in the agglutination of the organisms and subsequent embolism. Rabbits injected with *Staphylococcus aureus* toxin show similar capillary dilatation. Streptococcal infections, on the other hand, show dilatation of the glomerular vessels only and no emboli are seen. Semple, however, points out that in cases of mild staphylococcal infection there are no such changes, and, as these are the very cases in which renal lesions tend to occur, it is doubtful whether a great deal of significance can be attached to these observations.

From the above account it would appear quite possible that a lesion commencing as a small carbuncle might develop into a unilocal abscess by confluence of suppurating areas (as mentioned by Kretschmer⁽³⁵⁾). The possibility that a large carbuncle might proceed along such lines would, however, seem remote, although a multilocal abscess might be produced, the fibrous tissue septa remaining undissolved.

Clinical Types of Case.

According to the course they pursue, cases of renal carbuncle may be arbitrarily divided into three clinical types which correspond to the three pathological types.

By far the most common is the acute. In this the usual onset is with sudden pain in the loin or abdomen, high temperature, rigors and perhaps vomiting; less commonly with the more ingravescent development of pain and fever or more insidiously with the pain occurring only after some days or even weeks, during which signs of toxæmia have been manifest. A severely toxic state develops and is well established in seven to ten days. Occasionally a remission in symptoms may appear and the patient feel well for a few days, only to develop the above picture again—a dromedary type. Tenderness is present in the costo-muscular angle, usually from the onset, and towards the end of the second week a renal mass may become palpable. Urinary features are scanty, but *Staphylococcus aureus* may be isolated. A history of preceding superficial infection may be obtainable. Chromocystoscopy and pyelography will make the diagnosis with considerable certainty and surgical exposure of the kidney confirm it. The outcome of all cases in this acute group is one of three possibilities: operation is resorted to, or the patient dies without operation, or possibly spontaneous subsidence occurs within the first eight to ten weeks. The first mentioned is the usual event, and following it the patient may recover more or less rapidly, die, or pass into one of the next two groups (the last mentioned in a small percentage of cases in which the kidney has not been removed).

The subacute type of case may from the onset run a less severe course,^{(35) (37) (48)} and thus operative measures may be delayed for many weeks, or an acute case may pass into this group following inadequate surgery.⁽⁵⁵⁾ In all these cases the final surgical procedures are instituted by the end of the twenty-fourth week from the onset, or the patient dies without operation, or the condition subsides spontaneously during this period. This and the next type are uncommon.

The chronic type is again arbitrarily delineated on a time basis. Patients with a history of over six months' duration are placed in this group. Such patients may present constant low-grade features throughout, as in a case of twelve months' duration reported by MacMyn,⁽³⁸⁾ or symptoms may be intermittent, as in the cases of seven months' and four years' duration reported by T. D. Moore⁽⁴⁸⁾ and Klajman⁽¹⁷⁾ respectively. Finally, this type of case may follow an earlier inadequate operation; two such cases are reported by Ball,^{(2) (3)} one in which the patient had a urinary fistula following drainage of a perinephric abscess thirteen months previously, and the other in which the condition was diagnosed eight months after the drainage of a perinephric abscess, the wound of which healed rapidly.

Clinical Features.

A history of the primary focus is frequently obtainable. The first renal symptoms may occur from two days⁽²⁾ to many months^{(2) (3)} later, the usual limits being from two weeks to two months.

The onset is generally sudden or ingravescent with pain in the loin (occasionally the abdomen) and rigor. Unusually it may be insidious with unexplained general malaise. Less frequently still pleuritic pain may usher in the disease,⁽⁴⁸⁾ and rarely hæmaturia may be the first symptom.⁽⁴⁰⁾ In a case reported by Campbell⁽¹⁵⁾ the mother actually felt a mass in her baby's loin before realizing that the child was ill.

The pain at the onset is usually sharp and stabbing in nature and sudden in development, but may be of aching character and of more gradual appear-

ance. Renal colic is most unusual and in this series occurred in only three cases,^{(35) (49) (60)} in two of which^{(49) (60)} associated renal stone was present. It has been suggested by Ball^{(2) (3)} that pain occurs only when the perirenal tissues become involved, but others consider that the relief of intracapsular tension occurring at this time is rather the signal for diminution of pain (at least temporarily). The latter view is probably the more correct, because the very onset is so often suddenly painful, and, further, it has been shown that a carbuncle which has not reached the surface of the kidney in any place (second case reported by Dick⁽¹⁹⁾) has caused considerable pain. In those cases in which the pain has been referred to the abdomen acute appendicitis has been suspected; appendicectomy has been performed in such cases at least seven times,^{(36) (37) (38) (46) (52) (53)} and on one occasion operation for suspected acute cholecystitis was undertaken.⁽⁵⁴⁾ Although pain is an almost constant feature, it may be intermittent, and in those cases running a subacute or chronic course long intervals of freedom from pain are almost the rule.

Shivering and sweating are not unusual, and in acute cases rigors and vomiting are common. The temperature will vary from 103° to 106° F. in an acute case to a much lower range in those cases approaching the subacute type. The pulse and respiration rate are proportionate. Rarely, cough may be a prominent feature.^{(2) (3) (26)} Signs in the loin on the affected side are always present at some stage and usually from the onset. It cannot be over-emphasized that the area where these early signs are to be elicited is immediately in the costo-muscular angle. Tenderness here is almost invariable and rigidity may be present. Much later, deep oedema may be demonstrated (affection of perirenal tissues) and finally the diffuse swelling of a perinephric abscess may present in the loin. Very much earlier the affected kidney may be felt enlarged and tender, and later a renal tumour may be palpable (27% of cases). Psoas irritation (thigh flexion) is mentioned in two case reports.

Hæmaturia, as a symptom, is mentioned in four cases,^{(2) (3) (17) (35) (40)} but, apart from this rarity, urinary symptoms are conspicuous by their paucity. One patient had retention of urine following the onset of pain⁽²⁷⁾ and a third frequency of micturition.⁽⁴⁸⁾ (This excludes the two cases associated with renal stone and omits mention of a third with dysuria caused by urethritis, for which catheterization was responsible.) The comparative absence of urinary symptoms receives universal recognition. Doubtless it is to be correlated with the infrequency with which carbuncles communicate with the ureteric pelvis and the usual absence of gross pyuria.

The urinary findings are of considerable interest. It may be said that, whereas gross abnormality is rare, significant changes are frequent and that these changes assume a greater value on examination of the separate urine of the two kidneys. Further, frequent urinary examinations may be necessary if deviation from normal is to be detected, since abnormal constituents may appear in one specimen but not in the next. Forty patients had pus in the urine, usually in small amounts. Fifteen of these had the urine of the two kidneys separated, and in eleven unilateral abnormality was demonstrated, whilst in the remaining four cases the changes on the affected side were very much more pronounced. In fourteen cases red blood corpuscles were present (in two they were the sole abnormality). *Staphylococci* were cultured on sixteen occasions (*Staphylococcus aureus* fifteen times, *Staphylococcus albus hæmolyticus* once). Albuminuria is probably more common than is recorded and may be the only unusual feature. Crabtree⁽¹⁸⁾ has commented on the frequency with which cocci, seen on microscopic examination of the urine, are unable to be cultured. Whether this may occur in the case of *Staphylococcus aureus* is difficult to state, but microscopic findings of cocci in the urine may

prove of value, even when not confirmed by culture. Cabot⁽¹³⁾⁽¹⁴⁾ enters a plea for prolonged centrifuging before examination for organisms, maintaining that if this is done, they can regularly be found in the first few days following the appearance of renal features.

Special Features.

The leucocyte count varies considerably, usually being higher in the more acute cases. The lowest count recorded was 9,300 per cubic millimetre⁽⁴⁸⁾ and the highest 46,950 per cubic millimetre.⁽¹⁵⁾ A common count would be about 20,000 per cubic millimetre.

The percentage results of attempts at blood culture are not easy to state, as in few cases does this point seem to have been investigated. Aschner,⁽¹⁾ in his series of hæmatogenous staphylococcal renal lesions (all types), found four positive cultures in eleven cases; Beer⁽⁶⁾ obtained seven positive cultures in twenty-six cases. Such figures may be misleading if applied to renal carbuncle alone. Semple,⁽⁵⁷⁾ in one hundred and three cases of perinephric abscess, tried to produce blood cultures in "most cases" without obtaining a single positive result. Undoubtedly the number of positive results will vary with the stage and frequency with which culture is attempted in a given case. Diligent efforts at about the time of onset of symptoms would probably yield a quite high percentage, whilst cases in which a florid pyæmia exists⁽⁵²⁾ should give positive cultures.

It is not infrequent for a severe microcytic anæmia to be present—a fact which has not received due prominence. This may occur in any type of case. The most severe recorded is in a chronic case reported by MacMyn⁽³⁸⁾ (red cell count 1,960,000 per cubic millimetre, hæmoglobin value 28%). Very low figures are also reported by Campbell⁽¹⁵⁾ (red cell count 2,200,000 per cubic millimetre, hæmoglobin value 48%), T. D. Moore⁽⁴⁸⁾ (hæmoglobin value 35%) and Spence⁽⁵⁹⁾ (red cell count 2,790,000 per cubic millimetre, hæmoglobin value 50%).

Radiographic examination may yield findings of the utmost value. Without the help of pyelography one may demonstrate signs indicative of enlarged kidney, irritation of perirenal structures or perinephric abscess. The first needs no further comment. Irritation of perirenal structures may be suggested by diminished diaphragmatic movement⁽¹²⁾⁽¹⁴⁾⁽²⁶⁾ or by scoliosis with convexity to the unaffected side.⁽⁷⁾⁽¹²⁾⁽¹⁴⁾ Perinephric abscess and perhaps œdema of perirenal tissues may cause obscuration of the lateral border of the psoas muscle.⁽⁷⁾⁽¹²⁾⁽¹⁴⁾ Of the sixteen cases in which plain X-ray examination was resorted to, seven examinations gave negative results and nine positive (eight showed enlargement of the kidney and one obliteration of the psoas margin). Pyelographic findings are of even greater import and appear to be rarely negative. Fifteen excretion pyelograms revealed a unilateral abnormality in every case; eighteen retrograde pyelograms yielded sixteen abnormal results. Thus a normal pyelogram does not necessarily exclude a carbuncle, as must appear probable from a consideration of its pathology. The commonest findings in both types of pyelogram are obliteration of a calyx or calyces, filling defect or elongation, spreading or clubbing of calyces; rarely an extrarenal leak may be demonstrated by a retrograde pyelogram.⁽¹⁵⁾⁽⁴⁵⁾ An excretion pyelogram may, in addition, reveal a non-functioning area of renal tissue. Cabot⁽¹⁴⁾ uses it to demonstrate fixity of the kidney, due to adhesive perinephritis, taking films with the patient in the Trendelenburg and vertical positions; the normal renal excursion is the width of one vertebra.

Chromocystoscopy should rarely be omitted. It was performed in eighteen cases and gave results of lateralizing value in every instance. The delay

on the affected side may be slight or gross, depending largely on the amount of kidney tissue affected by the carbuncle.

Diagnosis and Differential Diagnosis.

The question of diagnosis involves a full consideration of three points: first, the site of the lesion; secondly, the nature of the lesion; and thirdly, the extent of the renal damage.

With regard to the first, it is generally not a difficult matter to determine that the kidney is the organ affected. Tenderness in the costo-muscular angle is invariable and usually present from the onset. It is at about this time that such a condition may be confused with an acutely inflamed appendix, especially one in a high retrocaecal position. However, a rigor is most unusual at the onset of acute appendicitis and the initial pain in this condition is classically umbilical or epigastric in distribution, later becoming localized in the right iliac fossa. It nevertheless must be remembered that with a retrocaecal appendix the initial pain may be in the loin. One must decide in favour of a renal condition on the early rigor, higher temperature range, the absence of the classical appendiceal pain sequence, the absence of an intestinal breath and the localization of the maximum tenderness to the costo-muscular angle. One or more of these features should sound the warning note and urinary findings may help to confirm it; Rovsing's sign may be of value, and the history of a recent superficial infection is of some significance.

Cases of less dramatic onset may have their nature recognized only after the lapse of some days, when the localizing pain and tenderness become more apparent or still later when the formation of a renal mass or perinephric abscess more clearly indicates a renal source. During this period frequent urinary examinations, including attempts to secure a culture, should be performed and, if possible, blood cultures should be assiduously attempted. Plain X-ray examination, pyelography and chromocystoscopy will usually demonstrate renal abnormality.

The second element of the problem—the nature of the lesion—now requires elucidation and resolves itself into two sections. First, one must diagnose a lesion of the metastatic staphylococcal group, and, secondly, attempt to place it in its correct subgroup. Renal conditions to be excluded are "primary" bacillary pyelonephritis, pyonephrosis, infected hydronephrosis and tuberculous kidney or renal neoplasm with or without secondary infection. The bacillary infections, primary or secondary, cause gross pyuria and their nature is established bacteriologically. In pyonephrosis radiography will probably reveal renal stones and pyelography demonstrate any dilatation of the renal pelvis; gross changes in the urine are present. Tuberculous kidney is liable to be confused with the more subacute types and is recognized by the discovery of tubercle bacilli in the urine. Once these conditions have been excluded, one must obtain positive evidence of staphylococcal infection—the culture of staphylococci from the urine. Persistent efforts in this respect should yield a high percentage of positive results. A staphylococcal blood culture would be equally decisive, whilst superficial staphylococcal infection of recent standing is very suggestive. Renal neoplasm is likely to be confused with only the chronic type of case, and is to be excluded by the demonstration of staphylococci in the urine or blood, whilst gross hæmaturia is very much in favour of neoplasm. Exactly similar variations in the pyelogram may be produced by these two conditions. Actual section of the kidney may be necessary to establish the differential diagnosis.

To assign the case to its subgroup in the staphylococcal infections is a matter of some difficulty. The kidney with multiple cortical abscesses gives a urine loaded with pus, red blood cells and staphylococci—in contra-

distinction to the paucity of the urinary findings in renal carbuncle. This fact alone is sufficient distinction. "Idiopathic" perinephric abscess must next receive attention. Such cases are comparatively common, and it is important to decide before operation whether or not a carbuncle is present in the underlying kidney. As observed by Semple,⁽⁵⁷⁾ who adopts the nomenclature of "acute perinephric abscess" for cases uncomplicated by gross kidney damage, such cases develop more rapidly after the initial symptom. This is, nevertheless, inadequate for sure differentiation. I consider that all patients with "idiopathic" perinephric abscesses should be subjected to retrograde pyelographic examination and chromocystoscopy. Deformity of the renal pelvis or definite diminution of renal function of one side as compared with the other indicates a gross renal lesion. Such a lesion is either a solitary unilocular abscess or a renal carbuncle. The distinction between these two can be made only at exploration.

With regard to the assessment of the extent of the renal damage, it is of considerable importance that this be estimated as accurately as possible before operation, since this information may help to determine the operative measures to be adopted. Chromocystoscopy is the method of choice. Minor degrees of delayed dye excretion would influence one towards preserving the kidney, whilst gross unilateral renal inefficiency, considered with other factors ascertainable at operation, may indicate nephrectomy. One must, as far as possible, ascertain that the affection is limited to the one kidney. The above measures, together with the examination of ureteric specimens, should solve this problem.

Prognosis.

In this series of eighty-four cases there were eighteen deaths—a mortality of 21%. The features which appear to influence the prognosis are as follows.

Age and Sex.—Table II suggests the effect of age on the outlook in the seventy-seven cases in which age has been recorded.

* TABLE II.
Age Incidence.

Age.	Cases.	Deaths.	Percentage of Deaths.
1-10	5	2	40.0
10-20	21	1	4.8
20-30	19	4	22.0
30-40	18	5	28.0
40-50	7	2	29.0
50-60	7	3	43.0
Total	77	17	—

It must be stated that the two deaths occurring in the first decade were those of infants aged eight weeks. Thus the extremes of life appear to be unfavourable periods, whilst the low mortality of 4.8% in the second decade would seem more than can be accounted for by coincidence. It is difficult to see why sex should have any effect on the course of the disease. In this series 60% of patients were males, whilst of the seventeen who died 76% were males. Thus the mortality rate in the male is higher than in the female. It is, nevertheless, felt that these figures do not permit of any generalization being made.

Blood Findings.—The leucocyte count appears to be of no value in prognosis. The highest count of the series was 46,950 per cubic millimetre,⁽¹⁵⁾ and was associated with the patient's death, while the lowest—9,300 per cubic millimetre⁽⁴⁸⁾—was followed by recovery; on the other hand, many patients with high counts have recovered and patients with low counts have died. The amount of circulating hæmoglobin seems to be of considerable import. Of the eighteen patients who died, as many as five^{(15) (38) (48) (59)} had grossly defective hæmoglobin values. Details of these have been given earlier and will not be recapitulated. One patient reported by T. D. Moore⁽⁴⁸⁾ with a hæmoglobin value of 58% recovered, but all other patients who recovered whose hæmoglobin values are mentioned, have this figure ranging from 70% upwards. In Case I of mine obvious gross anæmia was present, although its precise degree was not ascertained; this patient recovered after blood transfusion. The blood culture findings *per se* are of little value in predicting the outcome.

Flagrant pyæmia will naturally carry with it a grave prognosis, whilst affection of both kidneys indicates a probable fatal termination. Of the eight patients with bilateral renal involvement six died with gross pyæmic manifestations. The case in which a successful result was recorded by Beer, depends for its evidence of involvement of the second kidney on the discovery of adhesions at a subsequent operation on this kidney, whilst in the case recorded by Stuckey the patient recovered after drainage of bilateral perinephric abscesses. Actual details of this case I have been unable to obtain, and am dependent on Brady's acceptance of it as being bilateral carbuncle. My own case, in which there was a proved carbuncle on one side with simultaneous signs and symptoms of a gross renal lesion (not explored) on the other side, appears almost unique in respect of the patient's recovery.

TABLE III.
Analysis of Deaths.

Determining Factors in Deaths	Number of Cases.
Pyæmia + bilateral carbuncle	6
Pyæmia + unilateral carbuncle	1
Toxæmia + anæmia	4
"Jaundice" twelve months after nephrectomy	1
Peritonitis	2
Paravertebral abscess and thrombosis of inferior vena cava	1
Post-operative pneumonia	1
Operative injury of duodenum	1
Operative injury of pleura	1

Of the eighteen deaths reviewed in Table III, one can pick two in which a serious operative accident probably determined the fatal issue and a third in which an accurate diagnosis was possible and would have prevented the appendicectomy which may have been instrumental in causing the bursting of the carbuncle into the free peritoneal cavity three days after its performance. However, incidents such as this will probably always happen in any large series of cases, and the mortality of 21% is one which is likely to be materially improved only by some radical change in treatment, should future developments enable this to be made.

Treatment.

There is considerable difference of opinion with regard to the treatment which should be adopted in this condition.

Non-operative treatment has not been advocated, despite the evidence adduced earlier in this paper showing the possibility of spontaneous cure. In Case II, in which nephrectomy was performed on a kidney containing a carbuncle well on the way towards complete fibrosis, there is little doubt that recovery was already established. I do not assert that this is a common termination, but suggest that it is justifiable to temporize in the treatment of a patient with mild symptoms in the hope of such an occurrence.

In the vast majority of cases surgical intervention will be necessary, and this may be along radical or conservative lines. Various opinions are expressed as to the relative merits of these procedures. A consideration of the results obtained should be helpful in arriving at conclusions on this point. They are summarized in Tables IV and V.

TABLE IV.
Results of Conservative Operation.

Method.	Recoveries.	Deaths.	Percentage of Deaths.
Enucleation of carbuncle	5	0	0
Excision of carbuncle	4	0	0
Incision of carbuncle + drainage ..	5	0	0
Needling of carbuncle + drainage ..	0	1	100
Drainage of perinephric abscess ..	7	5	42
Total	21	6	—

TABLE V.
Results of Radical Operation.

Method.	Recoveries.	Deaths.	Percentage of Deaths.
Primary nephrectomy	37	6	14
Secondary nephrectomy	8	4	33
Total	45	10	—

Two patients not featured in these tables died, one of pyæmia which was not subjected to operation⁽⁵²⁾ and one consequent on the bursting of a carbuncle into the peritoneal cavity after appendicectomy,⁽³⁷⁾ undertaken owing to a mistaken diagnosis.

The conservative measures at our disposal are: enucleation of the carbuncle, excision of the carbuncle, incision of the carbuncle (in all these cases drainage of the renal area is provided) and simple drainage of an adjacent perinephric abscess when this is present. Over small series the first three methods were universally successful and thus merit most serious consideration. In all these cases there were carbuncles less than one-half the volume of the kidney.

The possibilities of enucleation^{(6) (16) (27) (49)} depend on the discovery of a cleavage plane. All carbuncles do not possess this plane, but if it can be found, enucleation would appear to be the treatment of choice. The method was accidentally discovered by Neff,⁽⁴⁹⁾ who was successful in one case. In a second case he was able to enucleate the carbuncle, but persistent toxæmic symptoms later caused him to remove the kidney, which showed no

suppuration. The patient died of pyæmia, which presumably would have happened even if a primary nephrectomy had been performed; virtually this was a successful operation.

Should enucleation prove impossible, excision of the carbuncle may be feasible⁽⁵⁾⁽⁵³⁾ and appears to be eminently satisfactory. Simple incision and drainage of the carbuncle⁽³³⁾⁽³⁶⁾⁽⁴⁸⁾ have yielded unimpeachable results.

In twenty-three cases the treatment adopted was the drainage of a complicating perinephric abscess. Seven uneventful recoveries ensued, in eleven cases secondary nephrectomy proved necessary, and five patients died without recovering sufficiently to permit of further surgical intervention. The obvious conclusion to be drawn is that drainage of an overlying perinephric abscess is infrequently successful, unless simultaneous or subsequent measures are directed towards the renal carbuncle itself. This treatment should be reserved as a primary procedure for very sick patients. It has its use in bilateral cases in which it is feared that an attack on the kidney may lead to primary nephrectomy, leaving an inadequate second kidney. That the kidney may still function after these conservative surgical procedures is shown by the presence of scars in many normally functioning kidneys,⁽¹⁴⁾ by subsequent excretion pyelograms (Cases I and II reported here) and by chromocystoscopy.⁽⁵³⁾ There seems no reason to think that such kidneys should be anything other than an asset to their owners. Urinary fistula may occur,⁽²⁾⁽³⁾⁽⁵⁾⁽⁶⁰⁾ but is unusual. Spontaneous closure of the fistula is the rule, although Ball⁽²⁾⁽³⁾ had once to perform secondary nephrectomy because of it.

The statement of Cibert and Klajman⁽¹⁷⁾ that convalescence after conservative surgery is stormy, seems not to be substantiated by these cases—convalescence was certainly no more stormy than it may be after primary nephrectomy—and any treatment which leaves the patient with two kidneys instead of one is surely to be recommended.

Whether one of these conservative lines of treatment can be adopted will depend largely on the size of the carbuncle. An attempt should be made to estimate this by chromocystoscopy (*vide supra*) and excretion and retrograde pyelography. Impressions formed from these data will be correlated with the condition as found at operation. Conservative measures can probably be attempted with carbuncles of a volume less than one-half that of the kidney. Difficulties of exposure may influence the surgeon in his decision. Enucleation, one suggests, should be performed whenever possible, and, failing this, excision, preferably with the diathermy knife. Incision of the carbuncle, from the theoretical standpoint, leaves much infected tissue and decapsulation appears to have no place (although useful in allied conditions). Very severely "toxic" patients should have any perinephric abscess drained as a first step.

Radical surgery consists in nephrectomy, either primary or secondary. This will be necessary in the treatment of large carbuncles—those involving more than one-half the volume of the kidney. One suggests that in these cases primary nephrectomy should be performed whenever the patient's general condition permits.

Cibert and Klajman⁽¹⁷⁾ point out the high mortality of secondary nephrectomy and use it as an argument in favour of their suggested treatment—primary nephrectomy in all cases. Actually the four deaths following secondary nephrectomy were due to post-operative pneumonia,⁽⁵⁾ "jaundice" occurring twelve months after operation⁽¹⁷⁾ and pyæmia in two cases;⁽²⁶⁾⁽⁴⁹⁾ in one of the two last mentioned there was a large carbuncle of the second kidney.⁽²⁶⁾ It would appear that in neither of these last two cases was the type of treatment adopted in any way responsible for the pyæmia, which was present throughout.

These considerations reduce the surgery of renal carbuncle to an eminently rational basis. Briefly, in all smaller carbuncles an endeavour should be to preserve the kidney, whilst large carbuncles should be treated by nephrectomy. Desperately ill patients with perinephric abscess should have the abscess drained at the primary operation, and when they are in better general condition a direct attack on the carbuncle should be essayed.

SUMMARY.

Three successful cases of renal carbuncle (one bilateral) are reported, and a total series of eighty-four cases are reviewed, eighty-one case records being obtained from a perusal of the literature.

The pathology of renal carbuncle is discussed in relation to that of other members of the metastatic staphylococcal group of renal lesion.

The importance of the complete investigation of all cases of "perinephric abscess" is emphasized.

On the basis of the results obtained in this series, a rational line of treatment for renal carbuncle is suggested.

REFERENCES.

- ⁽¹⁾ P. W. Aschner: "Staphylococcus Infection of the Renal Parenchyma", *The American Journal of the Medical Sciences*, Volume clxxii, 1926, page 63.
- ⁽²⁾ W. G. Ball: *The Proceedings of the Royal Society of Medicine*, Volume xx, iii, Section of Urology, page 716.
- ⁽³⁾ W. G. Ball: "Staphylococcal Infection of the Kidney", *The British Journal of Urology*, Volume x, 1938, page 322.
- ⁽⁴⁾ J. D. Barney: "Coccus Infection in and about the Kidney", *The New England Journal of Medicine*, Volume cciv, 1931, page 770.
- ⁽⁵⁾ Barth: "Der Nierenkarbunkel", *Archiv für klinische Chirurgie*, Volume cxiv, 1920, page 477.
- ⁽⁶⁾ E. Beer: "Coccic Infections of the Renal Cortex", *The Journal of the American Medical Association*, Volume cvi, 1936, page 1063.
- ⁽⁷⁾ E. Beer: "Roentgenographic Evidence of Perinephric Abscess", *The Journal of the American Medical Association*, Volume xc, 1928, page 1375.
- ⁽⁸⁾ W. Boyd: "Text Book of Pathology", Second Edition, 1934, page 171.
- ⁽⁹⁾ L. Brady: "Carbuncle of the Kidney (Metastatic Staphylococcal Abscess of the Renal Cortex)", *The Journal of Urology*, Volume xxvii, 1932, page 295.
- ⁽¹⁰⁾ G. E. Brewer: "The Present State of our Knowledge of Acute Renal Infections", *The Journal of the American Medical Association*, Volume lvii, 1911, page 179.
- ⁽¹¹⁾ G. E. Brewer: "Some Observations on Acute Unilateral Septic Infarcts of the Kidney", *Surgery, Gynecology and Obstetrics*, Volume ii, 1906, page 485.
- ⁽¹²⁾ H. Brunn and G. K. Rhodes: "Acute Hematogenous Metastatic Perinephric Abscesses", *The Journal of the American Medical Association*, Volume xciv, 1930, page 618.
- ⁽¹³⁾ H. Cabot: "A Relation Between Acute Infections of the Upper Respiratory Tract and Infections of the Kidney", *Surgery, Gynecology and Obstetrics*, Volume i, 1930, page 503.
- ⁽¹⁴⁾ H. Cabot: "Blood Stream Infections of the Kidney", *The British Journal of Urology*, Volume viii, 1936, page 233.
- ⁽¹⁵⁾ M. F. Campbell: "Renal Carbuncle in Infancy", *The Journal of the American Medical Association*, Volume xcvi, 1932, page 1729.
- ⁽¹⁶⁾ M. Chevassu: "À propos de l'enucleation des anthrax du rein", *Journal d'urologie*, Volume xliii, 1937, page 328.
- ⁽¹⁷⁾ J. Clibert and H. Klajman: "L'anthrax du rein", *Journal d'urologie*, Volume xlv, 1937, pages 273 to 299 and 353 to 397.
- ⁽¹⁸⁾ E. G. Crabtree: "A Method of Demonstrating Bacteria in the Urine by Means of the Centrifuge", *Surgery, Gynecology and Obstetrics*, Volume xxii, 1916, page 221.
- ⁽¹⁹⁾ B. M. Dick: "Staphylococcal Suppurative Nephritis (Carbuncle of the Kidney)", *The British Journal of Surgery*, Volume xvi, 1928, page 106.

- (20) J. L. Emmett and J. T. Priestley: "Solitary Renal Abscess (Carbuncle): Report of a Case", *The Proceedings of the Staff Meetings of the Mayo Clinic*, Volume xi, 1936, page 764.
- (21) H. Fischer: "Unilateral Septic Infection of the Kidney", *Annals of Surgery*, Volume lxvi, 1917, page 247.
- (22) M. P. Flandrin: "Un cas de volumineux abcès du rein à staphylocoques guéri par incision et drainage", *Journal d'urologie*, Volume xli, 1936, page 579.
- (23) A. R. Fritz and L. S. Drexler: "Renal Carbuncle", *The Urologic and Cutaneous Review*, Volume xxxv, 1931, page 703.
- (24) H. D. Furniss: "Report of a Case of Carbuncle of the Kidney", *American Journal of Obstetrics and Gynecology*, Volume xlii, 1927, page 650.
- (25) M. Goldstein: "The Pathogenicity of Cocci Isolated from the Urine", *Proceedings of the Staff Meetings of the Mayo Clinic*, Volume xlii, 1938, page 774.
- (26) R. C. Graves and L. E. Parkins: "Carbuncle of the Kidney", *The Journal of Urology*, Volume xxxv, 1936, page 1.
- (27) L. W. Hotchkiss: "On Excision of the Infarct in Acute Hæmatogenous Infections of the Kidney", *Annals of Surgery*, Volume lviii, 1913, page 227.
- (28) G. C. Huber: "The Arteriolæ Rectæ of the Mammalian Kidney", *American Journal of Anatomy*, Volume vi, 1906, page 391.
- (29) G. de Illyes: "Suppuration of the Renal Parenchyma", *The British Journal of Urology*, Volume ix, 1937, page 101.
- (30) J. Israel: "Metastatische Karbunkel der Niere", *Deutsche medizinische Wochenschrift*, Volume xxxi, 1905, page 1000.
- (31) W. Israel: Quoted by Cibert and Klajman, *loc. citato*.
- (32) T. G. I. James: "A Case of Carbuncle of the Kidney", *The British Journal of Urology*, Volume vi, 1934, page 156.
- (33) J. L. Joyce: "A Study of Staphylococcal Disease: The Renal Cases", *Guy's Hospital Reports*, Volume lxxx, 1930, page 169.
- (34) A. Kölliker: "A Manual of Human Microscopic Anatomy", 1860, page 403.
- (35) H. L. Kretschmer: "Carbuncle of the Kidney", *The Journal of Urology*, Volume viii, 1922, page 137.
- (36) J. A. Lazarus: "Carbuncle of the Kidney: Report of Two Cases", *The Journal of Urology*, Volume xxi, 1929, page 353.
- (37) B. Lipshutz: "Carbuncle of the Kidney", *Annals of Surgery*, Volume xciii, 1931, page 766.
- (38) D. J. MacMyn: "Carbuncle of the Kidney", *The British Journal of Urology*, Volume iv, 1932, page 11.
- (39) P. H. McNulty: "Carbuncle of the Kidney: Review of the Literature, Discussion of the Unilateral Localised Lesions and Report of a Case", *The Journal of Urology*, Volume xxxv, 1936, page 15.
- (40) Marion: Quoted by Cibert and Klajman, *loc. citato*.
- (41) Marion and Mora: Quoted by Cibert and Klajman, *loc. citato*.
- (42) E. G. Mark: "Carbuncle of the Kidney", *The Urologic and Cutaneous Review*, Volume xxvi, 1932, page 93.
- (43) A. A. Maximow and W. Bloom: "A Text Book of Histology", Third Edition, 1938, page 476.
- (44) J. A. Maxwell: "Renal Carbuncle", *The Journal of the Royal Naval Medical Service*, Volume xxiii, 1937, page 148.
- (45) H. Mayo and G. H. Burnell: "Carbuncle of the Kidney", *THE AUSTRALIAN AND NEW ZEALAND JOURNAL OF SURGERY*, Volume ii, 1932, page 205.
- (46) B. Meso: Quoted by Lipshutz, *loc. citato*.
- (47) T. Moore: "Metastatic Renal Lesions", *The British Medical Journal*, Volume i, 1939, page 819.
- (48) T. D. Moore: "Renal Carbuncle", *The Journal of the American Medical Association*, Volume xcvi, 1931, page 754.
- (49) J. H. Neff: "Enucleable Multilocular Abscess of the Kidney", *Annals of Surgery*, Volume xciii, 1930, page 506.
- (50) R. M. Nesbit: "Acute Staphylococcal Infections of the Kidney", *The Journal of the American Medical Association*, Volume xcvi, 1932, page 709.
- (51) V. J. O'Connor: "Carbuncle of the Kidney", *The Journal of Urology*, Volume xxx, 1933, page 1.

- (52) F. S. Patch and G. R. Reid: "Carbuncle of the Kidney with a Report of Two Cases of Bilateral Involvement", *The British Journal of Urology*, Volume v, 1933, page 33.
- (53) K. Reschke: "Über Paranephritis und Nierenkarbunkel", *Archiv für klinische Chirurgie*, Volume cxxix, 1924, page 303.
- (54) T. A. Rjasanzewa: Quoted by Brady, *loco citato*.
- (55) H. L. M. Roualle: "Carbuncle of the Kidney", *St. Bartholomew's Hospital Journal*, Volume xlv, 1938, page 220.
- (56) J. A. Ryle: "Perinephritis", *The British Journal of Urology*, Volume x, 1938, page 337.
- (57) J. E. Semple: "Perinephric Abscess", *The British Journal of Urology*, Volume xi, 1939, page 1.
- (58) A. W. Smirnow: "Ueber Nierenkarbunkel", *Zeitschrift für urologische Chirurgie*, Volume xx, 1926, page 245.
- (59) H. M. Spence: "Cabot Case 20071", *The New England Journal of Medicine*, Volume ccx, 1934, page 382.
- (60) H. E. Stedman: "Carbuncle of the Kidney: Report of Two Cases", *The American Journal of Surgery*, Volume xlii, 1938, page 410.
- (61) L. A. Stuckey: Quoted by Brady, *loco citato*.
- (62) W. N. Taylor: "Carbuncle of the Kidney", *The American Journal of Surgery*, Volume xxii, 1933, page 550.
- (63) T. Thompson: "Carbuncle of the Kidney, with a Report of a Case", *The Lancet*, Volume ii, 1927, page 695.
- (64) V. Vermooten: "The Mechanism of Perinephric and Perinephritic Abscesses", *The Journal of Urology*, Volume xxx, 1933, page 181.
- (65) R. Webster: "Pathological Reports from the Children's Hospital, Melbourne: Renal Carbuncle", *The Medical Journal of Australia*, Volume ii, 1938, page 205.
- (66) S. Williams and C. Timmins: "An Investigation of the Source of Staphylococcal Infection in Acute Osteomyelitis", *The Medical Journal of Australia*, Volume ii, 1938, page 687.
-

EXPERIENCES IN THORACIC SURGERY IN A BASE HOSPITAL IN THE MIDDLE EAST.¹

By E. S. J. KING,

Lieutenant-Colonel, Australian Army Medical Corps, Abroad.

DURING a period of four months sixty-six patients suffering from various thoracic conditions, the majority being battle casualties, were admitted to wards set aside mainly for their treatment. The following is a general account of these cases, the treatment adopted and the results obtained.

In the majority of cases the patients had been treated already for the immediate results of injury, such as hæmothorax and pneumothorax, and, with a few exceptions, arrived at hospital in relatively good general condition. Thus, for the most part, the problems were not urgent from the point of view of recovery of the patient and could be considered at relative leisure.

The cases observed were as follows:

Battle casualties (62 cases):

1. Wounds of the chest wall (without foreign body) ..	21
2. Foreign bodies in the chest wall	10
3. Through-and-through wounds	10
4. Foreign bodies within the chest	20
5. Crushed chest	1

Non-battle casualties:

Bronchiectasis	1
Hydatid of Lung	1
Empyema	2
Total	66

In the group of battle casualties the following complications were observed:

Diaphragmatic hernia	1
Pyopneumothorax closed	1
Pyopneumothorax open	1
Empyema	3

WOUNDS OF THE CHEST WALL.

Wounds of the chest wall consisted of: (a) tangential wounds; (b) wounds in which foreign bodies were present but were so superficial as to be removed through the wound without incision, or in which the foreign bodies actually fell out onto the dressings (three cases).

Of the 21 cases eight were of the tangential type. Four of the patients had large wounds, with considerable loss of tissue. They were treated by secondary suture or skin grafting.

The wounds were distributed as follows: four in the precordial and pectoral regions, seven in the dorsal and ten in the axillary and lateral regions of the chest wall. All the precordial and pectoral wounds in this group were tangential. The distribution of the wounds was governed probably by two factors. First, many wounds were received while the soldier was in a prone position or when only part of his body projected from cover. Secondly, precordial wounds—not tangential—fell into other groups or were fatal.

¹ Accepted for publication on December 22, 1941.

In three cases only was there indubitable evidence of associated intra-thoracic injury, though in five others there was a history of pain not easily explicable by the superficial wound itself. In all three cases a hæmothorax was present. This seemed to be due to damage to ribs, this opinion being supported by X-ray evidence in two of the cases. That pieces of bone are frequently projected into the chest cavity was indicated in cases in which operation was performed and direct observation was made.

In four of the laterally situated wounds there was injury to branches of the brachial plexus. In ten (of the 21 cases) there were injuries to other parts of the body.

FOREIGN BODIES IN THE CHEST WALL.

Of the ten foreign bodies found in the parietes, six had remained superficial and four had traversed some part of the lung before lodging finally in the opposite or adjacent part of the chest wall. Those mentioned in the previous section and classed (b) are not included here.

The foreign bodies were found in the following situations:

	Cases.
Pectoral muscles	2
Scapular muscles	3
Subscapularis muscle (deep to scapula)	2
Intercostal muscles	1
Erector spinae	1
Subcutaneous tissue (precordial)	1
Total	10

It will be seen that the ten cases, from the point of view of the extent and type of injury, fall into Group 1 (six cases) or Group 3 (four cases).

In addition, foreign bodies were found in the chest wall in cases in which there was an intrathoracic foreign body, but this dominated the picture and the superficial injury was relatively unimportant. They were found in:

	Cases.
Pectoral muscles	2
Scapular muscles	1
Subcutaneous tissues of the back	2
Total	5

THROUGH-AND-THROUGH WOUNDS OF THE CHEST.

There were ten cases of clear through-and-through wounds (with entrance and exit openings). These included two cases in which the missile had been just under the skin and had been removed in the forward area, but corresponded in every apparent way with those in which the projectile had escaped.

Of the ten cases the entrance wound was anterior in eight. In five the wounds were in the upper part of the chest; in three the wound was in the lower outer part of the chest and in two it was precordial, but the trajectory was obliquely outwards.

Complications consisted of hæmothorax, fracture of ribs, fracture of costochondral junction, diaphragmatic hernia and empyema.

In three cases a large hæmothorax was present on the patient's arrival at hospital and this was treated forthwith by aspiration. In five others a hæmothorax had been aspirated in the forward area. It was not clear in how many cases a pneumothorax had been present, but the severity of the symptoms suggested that it was almost invariable. Hæmothorax thus was

present in eight of ten cases. Hæmothorax was present in two of the four cases of perforating wounds in which the missile was retained in the chest wall (mentioned in the last section).

Empyema resulted from an inadequately aspirated hæmothorax in two cases and is discussed later.

Fracture of ribs was of no special moment and was found on X-ray examination. It may be mentioned that in two cases in which more gross

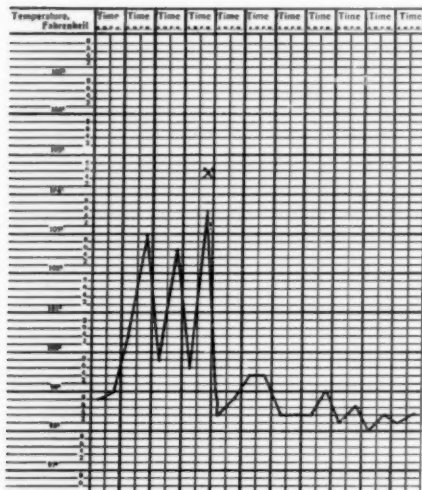


FIGURE I. Temperature chart of patient with an *empyema thoracis* (infected hæmothorax). X indicates the time of introduction of an intercostal tube. Negative pressure drainage was employed and convalescence was uneventful.

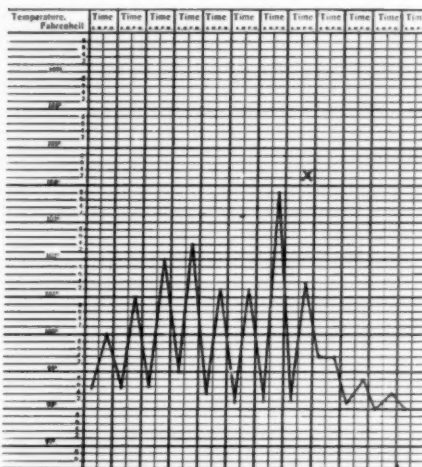


FIGURE II. Temperature chart of patient with an empyema following a through-and-through wound of the chest. X indicates the time of introduction of an intercostal tube (negative pressure drainage). Uneventful convalescence.

hæmorrhage had occurred into the pleura, injury to a rib was more apparent than in others, and this suggested that in these cases the bleeding came from an intercostal vessel. Fracture at a costo-chondral junction is mentioned specially since the symptoms (pain and tenderness) persisted for a much longer period than in the cases of injury to the bony part of the chest wall.

The diaphragmatic hernia is mentioned again later.

FOREIGN BODIES WITHIN THE THORAX.

Foreign bodies within the thorax were found as follows:

In lung	13
In pleura	4
In mediastinum	3
Total	20

Of the patients with pulmonary wounds three were lost sight of owing to various military exigencies. Of the remaining ten patients eight were operated on, the foreign bodies being removed, and two foreign bodies were so small that it was thought they should not be disturbed. Of the pleural missiles two were removed; two had been removed prior to the patients' admission.

Two of the mediastinal foreign bodies were removed, but the third patient—the foreign body being partly deep in the hilum of one lung and partly in the mediastinum—died before removal was attempted.

Thus of these cases the results were as shown in Table I.

TABLE I.

Site of Foreign Body.	Removed.		Not Removed.		Total.
	At Hospital.	In Forward Area.	Recovered.	Died.	
Lung	8	—	5	—	13
Pleura	2	2	—	—	4
Mediastinum	2	—	—	1	3
Total	12	2	5	1	20

The twelve patients operated on will be discussed in more detail in another paper.

CRUSHED CHEST.

One case of crushed chest is of interest in that the soldier was run over by a tank. He sustained a fracture of the left clavicle and at least six ribs. His recovery is due in part to the fact that he was in a ploughed field at the time of the injury.

NON-TRAUMATIC CONDITIONS.

Non-traumatic conditions do not require special discussion. The patient with bronchiectasis had a lobectomy of the left lower lobe performed and

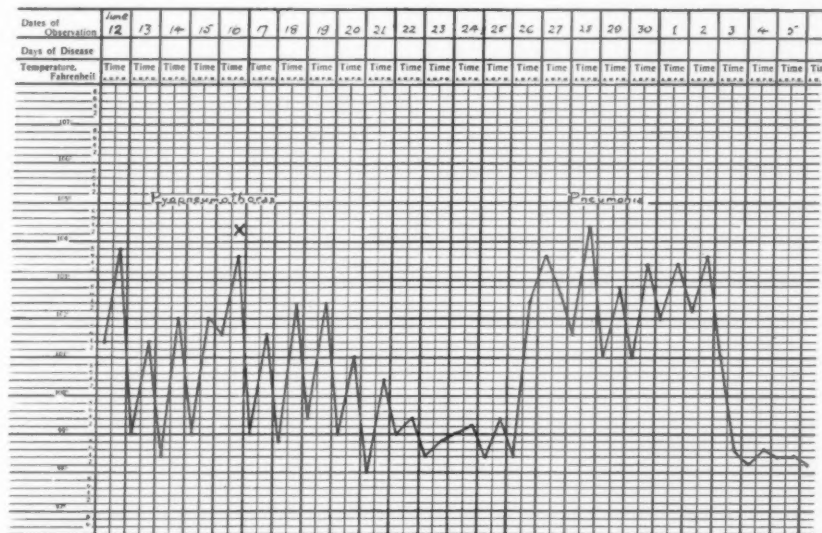


FIGURE III. Temperature chart of patient with a closed pyopneumothorax. Introduction of intercostal tube (with negative pressure drainage) at X. Subsequent progress satisfactory.

recovered satisfactorily. The hydatid of the lung ruptured into a bronchus during transport and the patient coughed up scolices. Haemoptysis continued for a time and gradually subsided.

COMPLICATIONS OF INJURIES.

The more serious complications deserve comment.

The diaphragmatic hernia was diagnosed on X-ray examination. The soldier had had, and apparently recovered from, a virtual through-and-through wound (the missile being removed from the chest wall). He continued to complain of epigastric discomfort. His condition was investigated to determine whether a second foreign body was present and the hernia was discovered. It was approached through the chest by means of a long intercostal incision in the eighth space. A relatively small opening was found, stomach and colon protruding into the pleural cavity without any covering sac. These were separated from the margins of the opening and returned to the abdomen and the opening was closed. Convalescence was uneventful.

The closed pyopneumothorax developed following rupture of an adhesion at the site of passage of a foreign body. Drainage was instituted and apart from a complicating lobar pneumonia (see chart) the patient made a satisfactory, though slow, recovery.

The open pyopneumothorax followed removal of a foreign body from the chest in a forward area. It developed apparently during transport. Closed drainage was instituted and recovery occurred slowly but progressively.

The details of the empyemata are given in Table II.

TABLE II.

Nature.	Site.	Site of Drainage.	Contents. (Cubic Centimetres.)	Organism.	Time of Drainage. (Days.)	Time of Healing. (Days.)
(1) Post-pneumonic	Right interlobar.	7th space outside scapular line.	500 thick.	Pneumococcus.	10	21
(2) Post-pneumonic	Left basal.	7th space outside scapular line.	450 thick.	Pneumococcus.	9	14
(3) Post-operative	Right upper under scapular.	5th space internal to scapular.	400 thin.	Staphylococcus.	12	16
(4) Post-traumatic (through - and - through wound)	Left axillary.	5th space—mid-axillary line.	50 thick.	No organism.	8	12
(5) Post-traumatic (through - and - through wound)	Right basal.	8th space—post-axillary line.	300 thin.	Staphylococcus.	6	17
Average time					9	16

GENERAL OBSERVATIONS.

Several features of these cases were sufficiently striking to make them worthy of special comment.

Degree of Damage.

In a number of cases the amount of damage to tissues was quite considerable, and when this is considered in conjunction with the disturbance associated with the entrance of air and fluid into the pleural cavity and the necessary changes in lung volume and distribution of blood in the vascular tree, it is astonishing that the individual was able to withstand it. It is, in part at least, an indication of the high standard of the treatment provided in the forward areas.

In four cases both sides of the chest were affected and in one the injury, obviously great, appeared to have been due to a machine-gun bullet travelling in its course through the chest at right angles to its long axis.

Rate of Recovery.

The rate of recovery was often astonishingly rapid. It depends on five principal factors: 1. Amount of tissue injury. 2. Restoration of normal conditions within the chest. 3. Presence of infection. 4. Necessity of movement (transport) of the patient. 5. Time of operative interference.

1. Little need be said about the amount of tissue injury; it would be expected that a patient with a large injury would recover more slowly than a patient with a small one. At the same time this factor is in itself less important than the more frequent association of intrathoracic disturbances with the larger injury. Thus a patient with a superficial injury from a large projectile was found to recover more rapidly than did one from, say, a through-and-through bullet wound in which a hæmothorax had been inadequately treated.

2. The removal of blood and air from the chest at the earliest practicable moment is most important. This has to be assessed, particularly at an early period, against the undesirability of disturbing a very sick patient who has

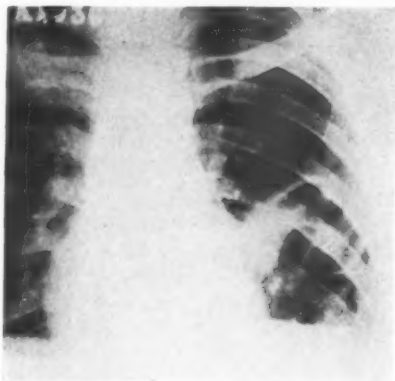


FIGURE IV. Skiagram showing a diaphragmatic hernia (following through-and-through wound of the chest).



FIGURE V. Skiagram showing the diaphragmatic hernia after induction of an artificial pneumothorax (prior to operation). Air-containing colon may be seen above the stomach.

compensated temporarily for diminution of vital capacity, and the possibility of recurrence of hæmorrhage. A sudden change in the condition of the patient may indicate the urgent necessity for interference when previously it had seemed to be, at the time, unnecessary. Each case therefore must be considered on its merits and considerable experience and judgement are required to deal adequately with many of them.

In some cases localization of fluid may be very difficult. So many changes occur as the result of the injury that demonstrable physical signs may be misleading. It is therefore often better to wait until all available methods of diagnosis are at hand rather than to attempt, more or less blindly, to locate a collection which may, for example, be between the lung and mediastinum. When these various aspects of the question are considered the original statement applies, that fluid should be removed as soon as practicable.

3. The presence of infection demands early intervention. The principles just stated apply here also, but in these cases the problem is more urgent.

It is eminently desirable that any procedure should be carried out, particularly in the early stages of convalescence from the injury, with as

little disturbance as possible. In this regard intercostal drainage by a tube inserted through a cannula was found to be ideal.

No other feature delayed the recovery so greatly as did the presence of even mild infection. In one case a small collection of pus (only 50 cubic centimetres) could not for a time be found, but when it was removed by drainage the improvement of the patient was truly astonishing, even though no organism could be cultured from the pus.

4. Transportation of patients was a most serious problem. As has been observed with all patients, too early movement causes most serious setbacks in their convalescence. This applies to even a greater extent, or perhaps it is more accurate to say for a longer period, in thoracic cases.

Not only is this true of the original injury, but it appears to apply to even a greater extent to patients operated on. It has been found that such patients, even though apparently well and able to walk about without distress or discomfort (and for considerable distances), have been seriously upset by a train or ambulance journey. This has an important bearing on the question of when and where any operative treatment should be carried out.

5. Certain operative treatment, such as the original closure of sucking wounds, cannot be instituted too early. Recovery of the patient from shock may begin to take place from this time. Any treatment, however, that can be delayed—for example, removal of foreign bodies—should be left until the patient is in some place where he can be nursed without further transportation for some weeks (at the very minimum two in the less severe cases). This is all the more essential when considerable distances have to be covered.

Types of Infection.

In several of the cases in which collections of pus were present within or round the chest wall, ordinary recognizable pathogenic organisms were found and demonstrated both on microscopic examination of smears and on culture. In some of them, however, no organisms were to be found on direct examination of the pus and, even though great care was exercised, no bacterial growth could be obtained on attempts at culture. This applied to one empyema and to several abscesses around foreign bodies. In others, organisms not corresponding to known pathogenic types were observed and cultured. The commonest form was a Gram-negative, non-lactose fermenting bacillus. Even in these cases the patient suffered a severe toxæmia which was relieved by drainage of the abscess or empyema. One clinically severe infection was associated with an anaerobic bacillus resembling, but different from, *Bacillus welchii*; despite the grave condition of the patient the organism did not prove fatal to a guinea-pig into which infected material had been injected.

Operative Treatment.

Two general principles only in regard to operative treatment need be mentioned here.

1. In almost all cases in which the chest was to be opened widely, unless there were demonstrable adhesions between the lung and parietes, an artificial pneumothorax was induced a few days before operation. In this way it was found that the operative procedure could be carried out without any great disturbance to the patient, and the quiet convalescence in all cases seemed to be due to this preliminary intrathoracic adjustment. The difference between these cases and those in which pneumothorax was not employed has determined the writer to use it in all practicable cases. Only once did a mediastinal "flap" occur, and this not of gross degree.

2. In all cases, both when fluid had to be drained from the chest (empyema, pyopneumothorax) and after operation, closed negative pressure

drainage was employed. The pressures employed were of the order of -5 to -10 inches of water, gradually increasing, in appropriate cases, to -4 to -8 centimetres of mercury on the fifth to seventh day. When thick pus was present pressures of -2 to -3 centimetres of mercury were used at the beginning.

The rapid healing of empyemata and the absence of post-operative complications demonstrated the value (and, in the writer's opinion, the necessity) of this adjunct to treatment. The post-operative empyema occurred in the upper part of the chest close to an area of infiltration (presumably infected) in the upper lobe of the lung.

It should be stated that drainage of this kind has been employed with success for mediastinal as well as pleural collections of fluid.

Late Treatment.

One of the striking features of all cases of chest injuries and operations is the diminution of the respiratory excursion on the affected side. This occurs in different degrees in wounds of the chest wall, in through-and-through wounds, with retained foreign bodies in the chest, in operations (particularly thoracotomy) and with empyema. This diminished excursion is usually associated with some pain; or discomfort which may be present continuously, but often, particularly in the later stages, is present only on deep inspiration.

This diminished pulmonary excursion may be overcome in a very short space of time if sufficient care and attention are given to dealing with it. At the earliest moment the patient is encouraged to breathe deeply at intervals during the day. He should be instructed in the differential use of the affected side of the chest. Explanations of an elementary kind to the patient of the inhibition of muscle action following injury and the necessity for conscious control of this are well worth while. After a short period the patient finds that a diminution of pain and discomfort on deep breathing occurs and he usually regards this an adequate reward for his efforts. As improvement occurs and the patient is allowed out of bed, breathing exercises for longer periods are given, graduated gymnasium exercises are begun and, where possible, swimming is indulged in. In a relatively short time (sometimes in three to five weeks) an almost immobile side of the chest becomes as automatically expansile as the other. Later, still more strenuous exercises are given. One point deserves emphasis: exercises should be begun as early as possible, and the *régime* should not be relaxed until chest movements are free. It was found, amongst the earlier cases, that lack of persistence in the early stages resulted in a distressingly disproportionate length of convalescence. It might be stated here that three days of breathing exercises are immeasurably better than three weeks or more of blowing Wolfe's bottles.

Almost all of the patients have been, or are in the process of being, returned to active duty. The exceptions are those who have other injuries—for example, peripheral nerve (seven cases)—and those in whom the severity of an infection justified prolonged convalescence (three cases).

SUMMARY.

1. A series of 66 consecutive cases of thoracic conditions observed during four months in a general hospital in the Middle East is described.
2. They include 62 battle casualties.
3. Only one death occurred amongst those in hospital.
4. Some observations on their symptomatology and treatment are made.

THE TREATMENT OF BURNS.¹

By W. A. HAILES,

Colonel, Australian Army Medical Corps, Abroad.

THE mechanization of industry and warfare and the flash of high explosives have rendered the treatment of burns a front-line problem of the first importance. Severe burns endanger the life of the sufferer, and require the mobilization of all the resources and the determination of the surgeon not only to save life, but to prevent and minimize deformity.

Readers of current medical and surgical journals must be interested and mystified as the protagonists of the varying treatments have their say in the Battle of the Burns. Those aspects of the treatment that have a physiological basis are readily understood. The more detailed discussions on technique appear so contradictory in principle and practice that the reader must be left wondering.

Treatment of the patient follows the accepted lines of that of shock. The clinical picture is that of shock unaccompanied by hæmorrhage, and these patients present a fertile field for the investigation of the physiological changes accompanying shock. The variations obtained in these numerous investigations have influenced the indications for treatment. An exhaustive article by D. A. K. Black in the *British Medical Journal* of November 23, 1940, does appear to prove the case for loss of fluid and protein from the circulation with resulting hæmo-concentration; it indicates how to measure the degree and the best means of combating that complication. Modern methods of resuscitation must be employed.

The treatment of the burn is not so simple. Individual surgeons suit their treatment and technique to their own environment and often fail, unfortunately, to realize the different surroundings and potentialities of those surgeons in other units who need advice. The Army cannot be over-impressed by what a few surgeons, working under ideal conditions, can accomplish; that is still a distant ideal. The Army is acutely interested in methods which under the conditions available will return 75% of all men with burns back to their original category. What is possible in a capital city cannot be contemplated in the Western Desert, where facilities are by comparison primitive and the necessary transportation a nightmare.

Many published articles, some of them by surgeons connected with the services, condemn tanning and advocate the saline bath and *tulle gras* method. This method has been perfected in England, where movement by ambulance is rapid and facilities for such treatment are readily available. In these circles "tanners" are condemned and "soakers" upheld. It can be stated with equal emphasis that in many forward battle areas this new treatment is impossible until present methods of evacuation have been revolutionized or circumvented. Transport to a base hospital in some cases necessitates movement by ambulance, boat, train and ambulance; if men with severe burns are to be submitted to this ordeal their burns must be tanned.

Between the excellent results obtained by the method of saline baths and *tulle gras*,⁽¹⁾ the equally good results following the treatment of second-degree burns by tanning (if this is carried out within a few hours of the burn) and the results in those cases in which tanning has been carried out at later intervals, the "variations are infinite".

¹ Accepted for publication on December 1, 1941.

Results obtained by tanning depend on the period that has elapsed before the treatment is carried out, the incidence and severity of infection and the depth of the burn. Extensive full thickness or third-degree burns cannot be expected to heal as do partial thickness or second-degree burns. This does not imply that tanning is incorrect treatment in all circumstances for burns that are in part full thickness burns. Extensive full thickness burns are best treated by baths and "Vaseline". In spite of the fact that third-degree areas tan badly, if at all, tanning may still be the best preliminary dressing for a large mixed second- or third-degree burn in view of the journey that has to be undertaken. The tanning treatment is the only one that will permit of transportation with some control of the loss of fluid and protein from the blood stream in the face of those difficulties encountered in the Middle East, or in civil life in many parts of Australia. The only rigid exception that could be taken to that general statement is that the "hands and face" should not be tanned. This applies particularly to the circumferential burns of the fingers. These regions of the body should be treated with "Vaseline".

Patients are admitted to casualty clearing stations in the Middle East many hours after the infliction of the burn; for these the bath treatment is a mirage, the base days away; the surgeon is confronted with a burn already infected, a minimum of equipment, a long journey to be accomplished and a life to be saved. With a full knowledge of the limitations of the method, most surgeons will turn to tannic acid and silver nitrate, treating special regions with *tulle gras* or "Vaseline".

It is unreasonable for the protagonists to laud one or other method without making a reasonable statement of the limitations as well as giving the usual glowing account of the advantages presented. The latter are always included, the former frequently conspicuous by their absence. Students and post-graduates, relying on the articles, accept the statements and cannot appreciate the limitations. This leads to criticism of treatment and the discarding of methods which, if unworthy of a place in a surgical Utopia, will save life and permit of travelling. It is particularly in this group of "infinite variables", as regards the number of hours of time lag and degree of infection before treatment can be instituted at a casualty clearing station, that the judgement, resource and technique of surgeons may be stretched beyond what it is reasonable to expect those attributes and methods to overcome. It must be remembered that the casualty clearing station is the first station along the line of communication where the extensive burn can be adequately cleaned and treated.

Those surgeons who have brought to the foreground the saline bath and *tulle gras* treatment have done a real service; the limitation of scarring and contracture in burns of the hands and face, with preservation of function, is an achievement. In the case of the hands this is aided by the readiness with which the patient moves the fingers in the bath; by comparison the tanned cast acts as a splint. This advance, though of the greatest importance today, is probably only a milestone in the final story of the surgical treatment of burns, and it should not be overlooked that, when it too has been modified or replaced by other methods, there may still be numbers of serious cases which, in the circumstances, will be best served by tanning. Excellent results are being obtained by the intelligent use of each method. If tanning has failed because of infection or because of the extent of the total skin damage, third degree, the cast should be cut away and saline bath and "Vaseline" treatment substituted. The granulating area must then be grafted at the earliest opportunity.

Certain facts do seem to be established:

1. As a means of treating burns in the Army the tan resulting from the use of the three-dye method is too soft and too easily removed by friction or trauma.

2. The most satisfactory tan is produced by using alternatively each of two solutions: 10% tannic acid and 10% silver nitrate. One application of each will suffice. This forms an efficient tan, more supple and less traumatizing than that resulting from tannic acid alone.

3. The time factor and efficient cleaning of the burn are two factors which must be considered together. It is not a question of how soon the sufferer is seen after the infliction of the burn, but how soon he can be efficiently treated and tanned, if tanning is to be carried out. Efficient treatment implies a general anaesthetic such as "Pentothal" (if veins are still available), the removal of the clothing, the cutting of all blisters and the removal of all undermined and loose epidermis (this must be removed up to the living edge). Removal is accomplished with dissecting forceps and scissors. The burnt area and surroundings are then cleaned with saline swabs; a brush must never be used. Alcohol or ether must be used only to remove grease if that is necessary prior to tanning. It is ideal to place the patient between sterile sheets and leave the burnt areas uncovered; if possible, sling the extremity to keep the tanned area away from the sheets and facilitate drying; posturing is also an assistance. Large tanned areas must not be covered with dressings after tanning. An electric light under the bed cradle helps to keep the cast dry.

4. When infection or liquefaction is present under the tan, soft areas appear and the fluid gravitates to dependent parts. Once this has occurred, the limb or burn should be immersed in saline solution, the cast should be cut away and the saline bath and "Vaseline" treatment substituted.

5. The edges of the burnt area after tanning should be painted with 2% gentian violet if available. The same should be done with the creases in the flexure lines. This helps to control infection.

As the time lag (before adequate treatment can be carried out) increases, so the chance of a successful tanning without infection decreases. It must be left to the surgeon on the spot, knowing the potentiality of the service immediately behind him, to decide whether: (a) to tan the burn and risk the infection in order to conserve body fluid and permit of transportation, or (b) to cover the burn with saline solution or "Vaseline" and send the patient to a "burn centre", or (c) even to send him there untreated except for the administration of morphine.

In the great majority of cases in the Middle East, knowing that some of the rules of the games are being broken, the surgeons in the forward areas have realized that tanning and evacuation to a better equipped hospital at the earliest possible opportunity hold most hope of success.

Experience shows that for the granulating surface saline baths, powdered sulphonamide and "Vaseline" dressings are the accepted treatment. The area is by this means very quickly prepared for skin grafting.

No attempt has been made to detail any of the accepted or newer methods of treatment. Accounts of how the saline bath treatment can be improvised in desert hospitals will in due course appear.

An attempt has been made to obtain some perspective on the counterclaim of the protagonists of what at first sight appear to be diametrically opposed methods of treatment, to indicate the limitations and the possibilities of these methods. What must be realized is: (a) that whole thickness burns—

that is, third-degree burns—tan badly, if at all, in the areas where the skin is completely destroyed; (b) that infection under the tanned area has brought the tannic acid treatment into disfavour. Suppuration under the cast results in progressive ulceration and destruction of tissue, with additional loss of skin and the development of scar tissue and subsequent contracture.

REFERENCE.

⁽¹⁾ "Discussion of the Treatment of Burns", *Proceedings of the Royal Society of Medicine*, November, 1940, page 43.

THE LOCAL USE OF SULPHONAMIDE COMPOUNDS.¹

By T. E. WILSON,
Captain, Australian Army Medical Corps.

THE original sulphonamide used therapeutically was red "Prontosil". Domagk showed that oral administration of this drug protected mice in which a lethal dose of streptococci had been injected into the peritoneum, but that this drug had practically no *in vitro* action on the same streptococci. Later when it was demonstrated that the active compound to which red "Prontosil" was reduced in the body was sulphanilamide, which had a bacteriostatic effect on streptococci *in vitro*, most surgeons still preferred the oral route for the administration, partly in the hope that sulphanilamide might undergo some further change in the body, thereby increasing its effectiveness.

The bacteriostatic effect of the sulphonamides is perhaps due to interference with an essential metabolite of the infecting organism, aminobenzoic acid (Woods⁽⁶⁰⁾); but regardless of the mechanism of the bacteriostasis, there is no doubt that this effect is partly dependent on the concentration of the drug to which the organism is exposed. In high concentrations there may be a bactericidal as well as an enhanced bacteriostatic effect. It is therefore not surprising that eventually a trial was made of the effect on infected wounds of the high concentrations of the sulphonamides produced by local application.

Jensen, Johnsrud and Nelson⁽²⁶⁾ (1939) were the first to demonstrate the great improvement attainable in the treatment of compound fractures by the local implantation of sulphanilamide (5 to 15 grammes) after painstaking *débridement*. The wounds were closed without tension, and in a series of 39 compound fractures and two compound dislocations primary wound infections were absent. In two cases the fractures of the tibiae were again allowed to become compound owing to inadequate splinting; both of these wounds became infected. Three years have passed since their paper was published, and although such results are unlikely with other lines of treatment, this method has not been universally adopted.

Fortunately, the importance of the local application of the sulphonamides in war wounds was soon realized, and it has become an established method of treatment in the British Army for lacerated wounds, compound fractures and burns requiring skin grafting. In the war of 1914-1918, Wright and Fleming pointed out that every wound produced by violent injury consists of a honeycomb of dead spaces between the muscle bundles, in the subcutaneous tissues and fascial planes, and that organisms grow profusely in the serous fluid in these spaces. Antiseptics which would penetrate to these spaces are either too damaging to the tissues or else soon lose their potency in the presence of body fluids. The sulphonamides do not suffer from such disadvantages. Usually, if the sulphonamide is placed in the wounds and is not pushed down into the crevices, it gradually diffuses to them and there exerts its effect on the organisms. In other cases it appears that these deeper spaces may become shut off from the main cavity of the wound, this diffusion being prevented with subsequent multiplication of organisms. This was found by the surgeons in France in 1940, and suggestions have been put

¹ This investigation was carried out during the tenure of a Senior Fellowship in Surgery at the Prince Henry Hospital, Sydney. The expenses were covered in part by a grant from the Royal Australasian College of Surgeons. Accepted for publication on February 26, 1942.

forward to overcome this difficulty. Legroux⁽³⁴⁾ introduced crayons of sulphanilamide and an emulsified form of the drug in a collapsible tube with a long nozzle. By these means the drug could be deposited in bullet wounds and narrow spaces. Jeffrey⁽²⁵⁾ reported the use of a hand pump introduced by Colebrook to blow the sulphanilamide powder throughout the wound. King⁽³³⁾ suggested that half a tablet be pushed into the corner of the wound with forceps, then crushed and the forceps withdrawn, the powder being left in the required position. Methods for the local application of the sulphonamides have been discussed recently by Hawking,⁽¹⁹⁾ who suggested the use of a pepper pot for superficial wounds, gauze passed through a thick aqueous paste for packing deep narrow sinuses, and pastes containing 30% sulphanilamide in various bases for superficial lesions.

Many ingenious combinations of the sulphonamides with other compounds have been suggested, especially for use as pastes; but sulphanilamide is insoluble in liquid paraffin and any effect of the sulphanilamide in such a suspension depends on the amount of the drug which falls to the bottom of the paraffin and is then dissolved in the tissue fluids. Similarly, sulphanilamide is insoluble in petroleum jelly; but, as the particles cannot gravitate through this substance, any effect of the sulphanilamide will depend on the few particles of the drug placed on the surface of the jelly. The slow rate of absorption of sulphanilamide from a suspension in liquid paraffin suggests its use for cases in which the lessened rate of absorption may be advantageous. There does not, however, seem to be any value in adding an inert compound (*vide* Poate⁽⁴¹⁾) such as iodoform to the paste as recommended by Jones.⁽²⁸⁾ It is also important that ensol should not be applied on top of a sulphanilamide dressing, for, instead of supplementing the effect of the sulphanilamide, ensol reacts with it to form an inactive product (Francis⁽¹⁴⁾).

REVIEW OF LITERATURE.

Since 1939 sulphonamides have been applied successfully to a wide variety of lesions, both external and in the body cavities. The reports of the successful use of these drugs include those of Colebrook,⁽⁹⁾ Colebrook and Francis,⁽¹⁰⁾ Buxton,⁽⁶⁾ Jeffrey,⁽²⁵⁾ Schneider,⁽⁴⁷⁾ King⁽³³⁾ (traumatic wounds), Mowlen,⁽³⁹⁾ Hooker and Lam,⁽²¹⁾ Vidas and McEachern,⁽⁵⁷⁾ Bickford,⁽²⁾ Robson and Wallace⁽⁴³⁾ (burns), Crile⁽¹¹⁾ (sympiotic gangrene), Campbell and Smith,⁽⁷⁾ Stuck, Maxwell and Monsalvo⁽⁵¹⁾ (compound fractures), Smith,⁽⁴⁸⁾ Brown⁽⁵⁾ (*empyema thoracis*), Childrey⁽⁸⁾ (nasal sinusitis), Rosenburg and Wall,⁽⁴⁴⁾ Jackson⁽²³⁾ (peritonitis), Long and Dees,⁽³⁷⁾ Thompson, Brabson and Walker⁽⁵⁴⁾ (acute appendicitis and appendiceal abscess), Johnstone⁽²⁷⁾ (hypopyon ulcer of the cornea), Thomas⁽⁵³⁾ (diphtheria carriers), Millet⁽³⁸⁾ (pneumococcal meningitis), Sams and Capland⁽⁴⁶⁾ (impetigo), and Wardle,⁽⁵⁸⁾ Eisenhammer⁽¹³⁾ (penetrating injury of the knee joint). Key and Burford⁽³⁰⁾ reported a reduction in post-operative wound infections when sulphanilamide was placed in all clean operative wounds. Varco, Hay and Stevens⁽⁵⁶⁾ implanted sulphanilamide about colonic anastomoses, but they had difficulty in evaluating the results in their few cases.

In a paper of this size it is not possible to do more than indicate a few of the articles dealing with the clinical use of the sulphonamides; but in many of these reported cases treatment has been empirical without any consideration of the type of infecting organism or of the possible deleterious effects on the tissues of the patient.

Experiments have been carried out to ascertain the effect of the local application of the sulphonamides on different types of wound infections.

These include those of Jensen, Johnsrud and Nelson⁽²⁶⁾ with *Staphylococcus aureus* and sulphanilamide, of Legroux⁽³⁴⁾ with streptococci and the anaerobic organisms of gas gangrene and sulphanilamide, of Bonnin and Fenner⁽³⁾ with *Staphylococcus aureus* and the anaerobic organisms of gas gangrene and sulphanilamide, of Hawking⁽¹⁷⁾ with the anaerobic organisms of gas gangrene and sulphanilamide, sulphapyridine and sulphathiazole, of Gordon and McLeod⁽¹⁶⁾ with the organisms of gas gangrene and sulphapyridine, and of Hudson, Smith and Selbie⁽²²⁾ and Rosenberg and Wall⁽⁴⁴⁾ with intestinal organisms and sulphanilamide. Although incomplete, these experiments provide a rational basis for the local use of the sulphonamides.

The experiments reported on the local effects of the sulphonamides on the tissues and on the rate of absorption of these drugs are also incomplete. In their rats, Rosenberg and Wall⁽⁴⁴⁾ found no peritoneal reaction attributable to the sulphanilamide implantation. Bonnin and Fenner⁽³⁾ were unable to detect any difference in the wounds of three guinea pigs packed with sulphanilamide and in control wounds. These authors were also unable to detect any peritoneal reaction to powdered sulphanilamide. From a study of the peritoneal exudate in rats in which 100 milligrammes of a powdered sulphonamide had been distributed throughout the peritoneal cavity, Throckmorton⁽⁵⁵⁾ found no reaction to sulphanilamide. Sulphathiazole produced a moderate and prolonged polymorphonuclear leucocytic response and an immediate and rapid increase in the mononuclear phagocytes, but did not cause any more adhesions than were found in the control group. Adhesions were frequent in the rats in which sulphapyridine had been implanted, the polymorphonuclear response was similar to that induced by sulphathiazole; but there was an immediate influx of lymphocytes followed by a steady increase in the mononuclear phagocytes. Sulphadiazine, sulphamethyldiazine and sulphanilylguanidine were somewhat more irritating than sulphathiazole. Key and Frankel⁽³¹⁾ implanted sulphanilamide, sulphapyridine and sulphamethylthiazole in wounds and joints of dogs, and in the pleural and peritoneal cavities and joints of rabbits, but found no significant changes. Key, Frankel and Burford⁽³²⁾ reported a complete lack of interference by powdered sulphanilamide with the healing of tendons in the rabbit. Vidas and McEachern⁽⁵⁷⁾ dusted sulphanilamide on the conjunctivæ of guinea-pigs and smeared with various bases containing sulphanilamide; in all animals signs of irritation were absent. Russell and Falconer⁽⁴⁵⁾ applied "Soluseptasine", solid sulphanilamide and sulphapyridine to rabbits' brains without causing any macroscopic alteration in the tissues. These authors suggested that the amount of dry powder used should be minimal, since both sulphanilamide and sulphapyridine produce a foreign body reaction in the brain. Glynn⁽¹⁵⁾ however, was unable to find any giant cell reaction to sulphanilamide, sulphathiazole or sulphapyridine implanted in the subcutaneous tissues of rabbits. The muscle and granulation tissue were affected by the drugs, and Glynn⁽¹⁵⁾ reported that sulphanilamide, probably owing to its greater solubility, is slightly but definitely more injurious to voluntary muscle than either sulphathiazole or sulphapyridine. A barely significant inhibition of fibroblastic proliferation was produced by sulphathiazole and sulphapyridine, but not by sulphanilamide. Glynn⁽¹⁵⁾ concluded that the injury of the muscle and the inhibition of the fibroblasts were too slight to contraindicate the use of these drugs in wounds.

Jacoby, Medawar and Willmer⁽²⁴⁾ applied sulphanilamide, sulphapyridine, sulphathiazole and sulphadiazine to fibroblasts, macrophages and epithelia *in vitro*, and concluded that, compared at equal concentrations, sulphathiazole is the most toxic of these drugs, but that toxicity under the conditions of clinical application is determined by their relative solubilities and falls into

the decreasing order: sulphanilamide, sulphathiazole, sulphapyridine and sulphadiazine.

Related to, but more important clinically than, any microscopic toxic change is the influence of the sulphonamides on healing tissues. Key and Burford⁽²⁹⁾ showed that implanted sulphanilamide did not affect the formation of callus and the healing of experimental fractures. Using the tensile strength of healing wounds of rats as an indicator of fibroblastic growth, Bricker and Graham⁽⁴⁾ concluded that sulphanilamide given orally had an inhibiting effect on the processes of repair; but with a similar method Taffel and Harvey⁽⁵²⁾ obtained normal healing. More experiments on the effect of the sulphonamides on the rate of healing are therefore necessary.

Glynn's figures⁽¹⁵⁾ for the solubilities in 40% serum at 39° C. in milligrammes per 100 millilitres are: sulphanilamide, 1,600; sulphathiazole, 200; sulphapyridine, 125. That the rate of absorption is related to the solubilities of the drugs has been confirmed for the peritoneum by Throckmorton⁽⁵⁵⁾ and for wounds by Hawking.⁽¹⁷⁾ If sulphanilamide is contained in the coagulating agent used for the treatment of burns, then absorption of the sulphanilamide ceases when the coagulum has formed (Vidas and McEachern⁽⁵⁷⁾). The highest blood sulphonamide level reported following local application is that of Hooker and Lam.⁽²¹⁾ Sixty grammes of sulphanilamide were sprinkled on a third-degree burn. Next day more powder was applied; the patient became cyanotic and confused, and the blood sulphanilamide level was 33 milligrammes *per centum*. Recovery occurred. Using smaller amounts of the drugs for local application, other authors have reported much lower values. Hawking and Piercy⁽²⁰⁾ inserted up to five grammes in wounds and obtained blood sulphonamide levels rarely above 1.5 milligrammes *per centum*. Hawking⁽¹⁸⁾ introduced sulphonamide compounds into one end of a tubular wound in the rat and showed that these substances diffused in order of their solubility in serum. He also found that the drugs would slowly penetrate dead tissue, but that they would not penetrate more than two millimetres into living tissue, being presumably washed away by the circulation.

The necessity for sterilizing sulphonamides before local application has been repeatedly discussed without any finality having been reached. Long and Dees⁽³⁷⁾ claimed that when sulphanilamide is autoclaved it breaks into its chemical components, often dissolving into a brown liquid. Key and Burford⁽³⁰⁾ sterilized their sulphanilamide by autoclaving for 30 minutes at 15 pounds pressure and then pulverized it if necessary. They affirmed that the autoclaved sulphanilamide had not lost its efficiency. Hawking⁽¹⁹⁾ recommends the sterilization of sulphanilamide in five-gramme lots in packets or bottles by dry heat at 150° C. for one hour. Contamination by the few hardy and impudent organisms which might exist on the sulphonamides is a theoretical possibility; but in most surgical clinics no provision is made for the sterilization of the drugs and no untoward results have been reported.

At Prince Henry Hospital sulphanilamide has been applied to more than one hundred and sulphapyridine to a few wounds, ulcers and other lesions. The purpose of this paper is to report the lessons learnt from these cases and the results obtained in some of them, and to report a series of experiments on rats in which sulphanilamide, sulphapyridine and sulphathiazole were buried in the tissues or body cavities.

CLINICAL RESULTS.

In most cases sulphanilamide has been used, but no significant difference in results or in the appearance of wounds was observed with sulphanilamide

or sulphapyridine. Powdered sulphanilamide was used in a few cases; in the others tablets of the drugs were crushed. No attempt was made to sterilize the tablets or the powder. It was assumed that the body was capable of dealing with the few organisms living on the surface of sulphanilamide or sulphapyridine tablets. The absence of contamination of clean wounds has justified this assumption. It is admitted that contamination, especially by spores of *Clostridium tetani*, might occur and that it would be wiser to use a sterilized preparation. The skin surrounding a wound to which a sulphonamide had been applied, was painted with triple dye in an attempt to prevent infection from sweat glands, hair follicles *et cetera*. "Metaphen" or "Merthiolate" would be more suitable than triple dye, but the cost of these drugs is prohibitive.

The advisability of reinforcing the local application of the sulphonamides by other routes of administration has been questioned; but owing to the gradual absorption the risk of toxicity is minimal when less than two grammes per stone of body weight are inserted in the wound. This risk may be further lessened by repeated estimations of the blood sulphonamide level, hæmoglobin value and leucocyte count. Hawking's experiments⁽¹⁸⁾ demonstrate that any organism more than two millimetres from the wound will be exposed to a concentration of the sulphonamide no greater than that in the blood. In order to control an infection which has spread beyond this local range of action of the drug, reinforcement of the local application is therefore necessary. Such reinforcement is also indicated for diffuse infections of the pleural and peritoneal cavities owing to the rapid absorption of sulphanilamide which occurs from these cavities. Whatever the route by which they are administered, the sulphonamides are secreted in the pleural and peritoneal fluids in the same concentration as in the blood.

Table I contains a summary of seventeen of the cases in which treatment was carried out by the local application of the sulphonamides. Included in this table are all the cases in which the results were not up to expectations. From a study of the cases in which local treatment by the sulphonamides was used, suggestions may be made for the future, and suggestions of other authors have been confirmed.

It must be emphasized at the onset that the local application of the sulphonamides is intended as complementary to the well established and proven procedures of surgery. For example, aseptic technique should be just as rigid whether sulphonamides are employed or not; and every attempt should be made in the wards to prevent wound infection, for this may still occur when absorption of the drug is complete. If a traumatic wound is very soiled, there is no contraindication to irrigation of the wound with proflavine before application of the sulphonamide.

With early treatment, complete *débridement* and adequate fixation of compound fractures, primary healing may be obtained without the aid of chemotherapy; but since *débridement* may be unwittingly incomplete and primary healing fail to occur, it is recommended that before the wound is closed sulphanilamide be inserted. Ten to twenty grammes of the drug should be used, depending on the size of the wound and of the patient. If infection has become well established by the time of operation, less success is to be expected from local chemotherapy even when it is reinforced with chemotherapy by another route. In such cases the wound should not be closed after insertion of the sulphanilamide, but should be covered with a "Vaseline" pack. It is just as important as formerly to exclude all foreign bodies and devitalized tissue from the wound. The immobility provided by a complete plaster on the injured limb accelerates the rate of healing irrespective of the use of chemotherapy.

Compound fractures treated early should be drained only if it is feared that *débridement* is incomplete. In these and other cases in which local chemotherapy is used, drainage should not be provided at the most dependent region, for the sulphonamide may leak out. Some surgeons have worried about

TABLE I.

Summary of Some of the Cases in which Treatment by Local Implantation of the Sulphonamides was Used.

Name.	Sex.	Age. (Yrs.)	Diagnosis.	Amount of Drug Inserted. (Grammes.)	Additional Treatment.	Result.
V.H.	M.	22	Compound fracture of tibia. Severed patellar tendon.	10 ¹	Debridement tendon suture. Wound closed. Reduction and plaster.	Wound completely healed in three weeks.
T.S.	F.	13	Septic arthritis of hip (<i>Staphylococcus aureus</i>).	6 ¹	Arthrotomy and closure.	Purulent discharge from wound. Bony ankylosis.
C.G.	M.	39	Secondary carcinoma of metacarpal with sinus.	2 ¹	Biopsy and closure.	Sinus recurred.
W.K.	M.	45	Brodie's abscess of left tibia (<i>Staphylococcus aureus</i>).	3 ¹	Trephination and closure.	Slight oozing for one week, then healed.
D.M.	M.	56	Chronic osteomyelitis of femur.	6 ¹	Sequestrectomy. Wound left open.	Sinus persisted due to inadequate drainage.
P.S.	M.	45	Chronic osteomyelitis of femur.	3 ¹	Sequestrectomy. Wound left open.	Healed in three weeks.
W.B.	M.	30	Empyema of frontal sinus. Acute osteomyelitis of frontal bone.	3 ¹	Drainage of frontal sinus. Wound packed daily with three grammes of sulphapyridine.	Death. Extradural abscess found at autopsy.
I.W.	F.	31	Acute empyema thoracis (pneumococcus).	3 ¹	Rib resection. Closed drainage. (Drug in wound only.)	Healing delayed six weeks due to frequent blocking of tube by fibrin.
A.M.	F.	26	Acute empyema thoracis (pneumococcus).	3 ¹	Rib resection. Closed drainage. (Drug in wound only.)	Healed in two weeks.
R.P.	F.	13	Acute gangrenous appendicitis.	4 ¹	Appendicectomy. Not drained.	Pelvic abscess. Intestinal obstruction.
O.C.	M.	13	Appendiceal abscess.	2 ¹	Drainage only.	Healed in four weeks.
D.W.	M.	48	Pilonidal sinus.	17 ¹	Excision and closure.	Excess of drug prevented early obliteration of cavity.
C.S.	M.	26	Pilonidal sinus.	2 ¹	Excision and closure.	Healed in nine days.
P.O.	M.	66	Gangrene of foot following ligation of popliteal aneurysm.	12 ¹	Excision of gangrenous area.	Healthy granulation tissue developed in a week.
R.B.	M.	21	Symbiotic gangrene of axilla.	5 ¹	Excision of edges.	Improvement, but healing not complete.
P.L.	F.	2	Third degree burn of chest.	2 ¹	Reverdin's grafts.	Healing accelerated.
T.M.	M.	40	Chronic varicose ulcer. Unhealed for eight years.	4 ¹	(Dressing unchanged for six days.) No other treatment used.	Healed in twelve days.

¹ Sulphanilamide.

² Sulphapyridine.

the possibility of a foreign body reaction to the local use of the sulphonamides, but drain tubes are used by many without a thought for the great foreign body reaction which results. Where compatible with safety, drainage should be omitted when local chemotherapy is employed.

Pus and necrotic tissue inhibit the bacteriostatic action of the sulphonamides, because of the peptone (Spink⁽⁴⁹⁾) and other products of protein digestion they contain. Because of this and because the drugs cannot diffuse throughout the inflammatory zone in osteomyelitis, poor results have attended the local use of sulphonamides in this disease. The limited vascularity and relative inelasticity of bone, *Staphylococcus aureus* as the common infecting organism, and the frequent occurrence of sequestra all militate against the success of local chemotherapy. It is therefore still necessary to provide drainage and to remove all sequestra as formerly practised. Chemotherapy by other routes has a place in the treatment of the early case of osteomyelitis, but in these and later cases local chemotherapy alone has not. Drainage is also essential in the treatment of appendiceal abscesses (if operated on), of septic arthritis and of acute *empyema thoracis*, even if local chemotherapy is employed. This does not mean that local chemotherapy is useless in such cases; rather, local chemotherapy plus drainage represents the advance in treatment.

Four pilonidal sinuses have been treated by excision, implantation of sulphanilamide and closure. The bowels were confined for five days, and then the wound was swabbed with triple dye and powdered with sulphanilamide after each bowel action. In three of the cases primary union took place; but in the fourth—an extensive lesion with multiple openings—17 grammes of sulphanilamide were inserted after excision and before closure. The drug was not completely absorbed for seven days, by which time the centre of the wound had opened. The base of the wound and the deep surfaces of the skin flaps then presented clean granulations. The cavity was repeatedly packed with sulphanilamide and gauze, and the skin painted with triple dye. Previous unsuccessful attempts at excision had been made, so that the patient made no complaint when he was discharged within five weeks with the wound practically healed.

The mistakes in this case were the use of too much powder at the operation (17 grammes) in an endeavour to obtain an even better result than in the other cases, and the failure to insert deep sutures through the base of the wound to obliterate the cavity. Not more than three grammes were inserted in the other three cases, all of which healed by first intention.

This is the only case in the series in which a delay in the healing might have been blamed on the sulphonamides. In most cases healing was accelerated due to the elimination of infection.

Sulphonamides may sometimes cause a rise of temperature and even a leucocytosis; but when these signs are present the search for other foci of infection should be thorough before their absence is assumed.

In a case of empyema of the frontal sinus complicated by acute osteomyelitis of the frontal bone temporary improvement followed drainage of the sinus and packing with sulphapyridine. A week later, since examination of the central nervous system and the cerebro-spinal fluid revealed no abnormality, the osteomyelitis was subsiding and no other obvious focus of infection was discovered, the rise in the temperature and the leucocytosis were attributed to the effect of the sulphapyridine. Death occurred suddenly and autopsy revealed an extradural abscess.

Among the patients most grateful for local treatment with the sulphonamides have been those with chronic varicose ulcers of long duration which have ceased to respond to the usual method of treatment. If the infection was not overwhelming and if the circulation was not too inefficient, good results were obtained. The drug used for most superficial lesions has been sulphanilamide. Any exudate was removed with saline solution; the skin edges, but not any ingrowing epithelium, were painted with triple dye; and then a layer of the drug a quarter of an inch thick was applied to the lesion. The whole area was protected by gauze smeared with "Vaseline", and then covered completely with adhesive strapping. The dressing was left undisturbed for one week. Healing is naturally accelerated if it is

possible for the patient to rest, and if the veins are ligated and retrograde injection is performed.

Other superficial lesions, such as decubitus ulcers, symbiotic gangrene and infected radionecrotic ulcer, have been similarly treated with success.

In a case of third-degree burn of the chest, successful skin grafting was carried out after preliminary treatment of the granulating area with sulphanilamide, although several previous attempts in which sulphonamides were not employed had failed (Figures I and II).

Success on this occasion was almost certainly due to the disappearance of the non-haemolytic streptococci from the lesion under the action of the sulphanilamide.

As a prophylactic measure one or two grammes of sulphanilamide have been dusted about the suture lines of intestinal anastomoses and wounds of the abdominal wall in cases of perforated peptic ulcers, perforated appendices and in other cases in which the intestine has been opened. Wound infections appeared to have been reduced; but as the patients recovered there has been



FIGURE I. P.L., aged two years. One week after the onset of treatment with sulphanilamide, showing the commencing epithelialization.



FIGURE II. P.L., aged two years. This photograph was taken two months after Figure I. During this time the granulating surface had been treated with sulphanilamide, and Reverdin's grafts had been inserted. Showing the burn completely healed.

no opportunity to examine the bowel later. For the prevention of infection of gangrenous lesions, either primary vascular or diabetic, sulphanilamide powder seems to be a useful dressing.

In cases of diffuse peritonitis, acute *empyema thoracis*, erysipelas and spreading cellulitis no reliance has been placed on local application alone, for the blood concentration is the important factor in these cases.

The conditions in which the local use of the sulphonamides has been practically valueless were those in which there was a considerable amount of pus, such as carbuncles and abscesses, and those in which the infection was superimposed on a malignant process. In this series no tuberculous ulcer or gumma was treated by local chemotherapy; but with these specific infections any improvement would be due only to the control of secondary infections.

EXPERIMENTAL RESULTS.

Technique.—Male white rats weighing between 200 and 250 grammes were used. Under "open ether" anaesthesia the skin was shaved, an incised wound was made, one of the drugs was inserted, and then the wound was

closed with cotton sutures. In 17 rats used as controls wounds were made or the body cavities were opened and closed without insertion of the drugs. Contamination of the wound was reduced as far as possible, but no dressings were applied. Tablets of the drugs, crushed or uncrushed, were used. Blood for cell counts and hæmoglobin estimations was obtained by clipping the tail. Death was produced by opening the pleural cavity under "open ether" anaesthesia. Blood for sulphonamide estimations was taken directly from the heart. Sections of the femoral marrow were fixed in Helly's fluid and stained by May-Grünwald-Giemsa method. Decalcification was omitted. Marrow smears were prepared by emulsification in serum, which was spun down, the deposit was spread and stained by the Leishman method. For differential counts on the blood 200 cells were counted, and on the marrow smears 500. Liver sections for glycogen were fixed in dioxane picric acid and stained with Best's mucicarmine stain. Other sections were fixed in 5% formol saline solution and stained with hæmatoxylin eosin.

Experiment I.—Experiment I was a control. Incised wounds of skin and muscle were sutured without insertion of sulphonamides. Nine rats were used. They were killed at intervals from one to twenty-nine days. Pieces of fine gauze were put under the skin and in the peritoneal cavity of two rats. They were killed after nineteen days.

Apart from some infection, as evidenced by accumulation of polymorphonuclear cells, and a few foreign body giant cells around the sutures, all the wounds healed rapidly. In both rats in which the gauze was inserted, numerous foreign body giant cells were arranged around the gauze fibres.

Experiment II.—Experiment II consisted in the insertion beneath the skin of 0.5 gramme of sulphapyridine (six rats, killed at intervals from five to fifty-nine days), sulphathiazole (six rats, killed at intervals from two to thirty-seven days) and sulphanilamide (five rats: two died within twenty-four hours of operation, others killed on second, twelfth and twenty-sixth days).

The absence of infection in these wounds was in contrast with the slight infection associated with the sutures in all the animals of Experiment I.

On section of the wounds in which one 0.5 gramme uncrushed tablet had been inserted, sulphapyridine had disappeared by thirty-two days, sulphathiazole by ten days

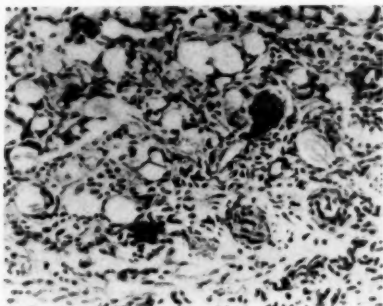


FIGURE III. From rat in which 0.5 gramme of sulphapyridine had been inserted under the skin twenty-two days previously. Showing the spaces which had contained sulphapyridine, embedded in young fibrous tissue with a few foreign body cells.

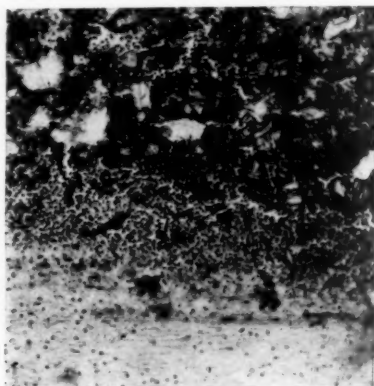


FIGURE IV. From rat in which 0.5 gramme of sulphathiazole had been inserted under the skin two days previously. Showing crystals of the drug surrounded by cellular debris around which were numerous polymorphonuclear cells.

and sulphanilamide by one day. Within five days granulation tissue appeared around and between the particles of sulphapyridine (Figure III) and gradually gave place to a fibrous tissue capsule. A few foreign body giant cells also developed around the particles. The extent to which the granulation tissues and the fibrous tissue invaded the tablet proved the absence of any significant inhibition of fibroblastic proliferation. When the sulphapyridine was completely absorbed a small scar remained. The increased

rate of absorption of sulphathiazole was confirmed microscopically; and the fibroblastic reaction was much less than with sulphapyridine (Figure IV). Many fewer giant cells were seen in juxtaposition with crystals of sulphathiazole and sulphanilamide than with sulphapyridine. The rapidity with which sulphanilamide dissolves may be the reason for the slight cellular reaction to this drug (Figure V). Within a day of implantation of one tablet of sulphanilamide this area was indicated by only a small amount of yellow fluid in a cavity surrounded by fibroblasts, lymphocytes and a few foreign body giant cells.

Experiment III.—Experiment III consisted in the insertion into the *pectoralis major* of 0.25 gramme of sulphapyridine (twelve rats, killed at intervals from four to thirty-eight days), sulphathiazole (ten rats, killed at intervals from four to twenty-four days) and sulphanilamide (ten rats, killed at intervals from one to twenty-six days).

In one rat in which sulphanilamide was inserted, infection developed three weeks later. It is assumed that owing to the rapid absorption of sulphanilamide, no protection would be afforded by the drug after this time. With this exception and with the exception of invasion by granulation tissue between the surface muscle fibres near to the drug (Figure VI), other changes in the muscles of these rats were probably due to

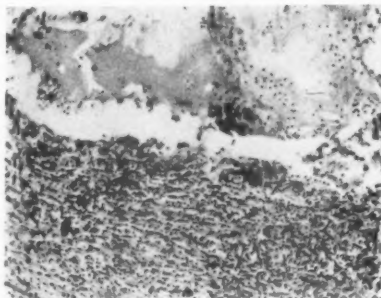


FIGURE V. From rat in which 0.5 gramme of sulphanilamide had been inserted under the skin twelve days previously. Showing the edge of the cavity which contained fluid, but no crystals of the drug. The cavity was lined by fibroblasts, lymphocytes, plasma cells and capillaries, all of which appeared normal.

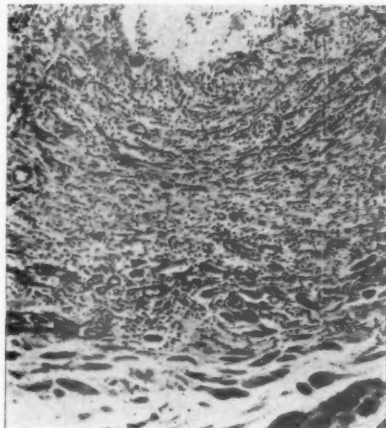


FIGURE VI. From rat in which 0.25 gramme of sulphapyridine had been inserted into the *pectoralis major* twenty-two days previously. Showing the cavity which had contained the drug, surrounded by fibroblasts and lymphocytes and beyond which was granulation tissue. Some of the muscle fibres on the surface have been invaded by the granulation tissue and were atrophic.

the trauma of the operation and not to the sulphonamides. Breast tissue was included with the muscle in the sections from two rats, but showed no abnormality.

Experiment IV.—Experiment IV consisted in the insertion into the peritoneal cavity of sulphapyridine (twenty-two rats, five of which died within twenty-four hours of operation, others killed at intervals from one to thirty-two days), of sulphathiazole (eight rats, two of which died within twenty-four hours of operation, others killed on the first or the tenth day) and of sulphanilamide (six rats; two died within twenty-four hours of operation, others killed at intervals from one to twenty-one days). The amount of drug inserted varied from 0.25 to 3.0 grammes. If the drug was surrounded by omentum this was removed for sectioning. Tissue was also taken for sectioning from liver, small bowel and in a few animals from kidney, pancreas and abdominal wound. In two rats the peritoneal cavity was opened and closed without the insertion of any drug. Tissue was taken for sectioning from liver, small bowel and abdominal wound of these rats.

In two of the rats in which sulphapyridine was inserted in the peritoneal cavity, but not in the wound, examination of the wound revealed small abscesses seventeen and twenty-two days after operation. In each of these cases the blood sulphapyridine level was then zero. In the other rats of this experiment the wounds and parietal peritoneum appeared normal with the exception of two rats in which 0.5 gramme of sulphathiazole was inserted in the peritoneal cavity the previous day. In both, crystals of the drug were adherent to the inner surface of the wound and caused a subperitoneal polymorphonuclear reaction (Figure VII).

In most of the rats in which sulphapyridine was inserted in the peritoneal cavity the drug was soon surrounded by a capsule of granulation tissue and, later, fibrous tissue formed from omentum (Figures VIII, IX and X). A few peritoneal adhesions were also present, but no other evidence of an inflammatory reaction was seen in these rats (Figure XI). In seven of the rats in which sulphapyridine was inserted, the drug was absorbed before becoming encapsulated. Whether the sulphapyridine was completely absorbed or whether a capsule developed

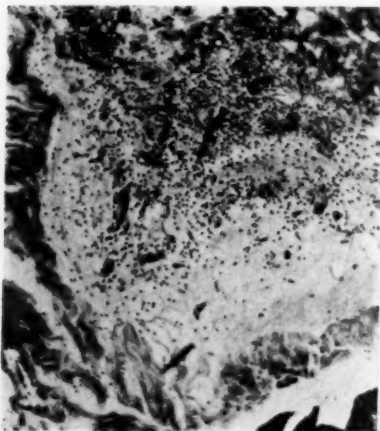


FIGURE VII. From rat in which 0.5 gramme of sulphathiazole had been inserted in the peritoneal cavity the previous day. Showing crystals of the drug and cellular debris on the surface of the peritoneum, with the subperitoneal tissue edematous and infiltrated with polymorphonuclear cells and lymphocytes.

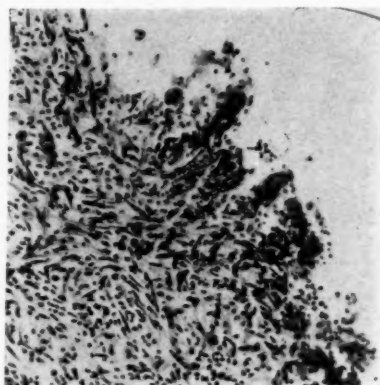


FIGURE VIII. From rat in which 0.5 gramme of sulphapyridine had been inserted in the peritoneal cavity five days previously. Showing the young fibroblasts with lymphocytes and polymorphonuclear cells in edge of the capsule formed by the omentum around the drug.

from omentum was independent of crushing and dispersing the tablets. In one rat a 0.5 gramme tablet (uncrushed) of sulphapyridine was absorbed within eleven days of operation, whereas in another rat most of the drug was still present after fourteen days, although the tablet had been crushed and dispersed.

In the rats in which 0.5 gramme of sulphathiazole was inserted in the peritoneal cavity, most of the drug was absorbed within twenty-four hours of operation; but that which remained was not surrounded

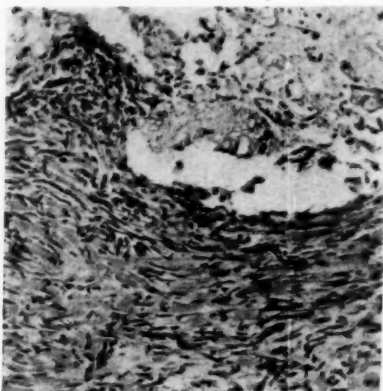


FIGURE IX. From rat in which two grammes of sulphapyridine had been inserted in the peritoneal cavity twenty days previously. Showing the cavity with the clefts containing crystals of the drug, and the thick wall of young fibrous tissue formed from the omentum.

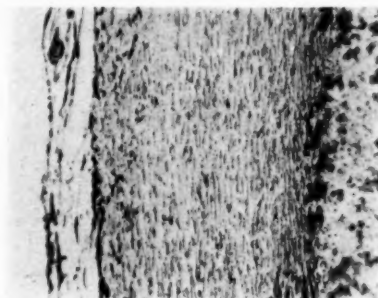


FIGURE X. From rat in which 0.5 gramme of sulphapyridine had been inserted in the peritoneal cavity six days previously. Showing the capsule of young fibrous tissue formed from omentum around the unabsorbed drug.

by omentum or adhesions. In the rats in which more than 0.5 gramme was inserted, absorption took proportionately longer; but in none of these rats was there more than a transient subperitoneal polymorphonuclear response produced by sulphathiazole, and then only when crystals of the drug were adherent to the peritoneum (Figure VII).

Within twenty-four hours 0.5 gramme of sulphanilamide was absorbed from the peritoneal cavity. No peritoneal reaction was produced by this drug.



FIGURE XI. From rat in which 0.5 gramme of sulphapyridine had been inserted in the peritoneal cavity eleven days previously. Showing the bowel and mesenteric attachment without any inflammatory reaction. At death the drug was completely absorbed.

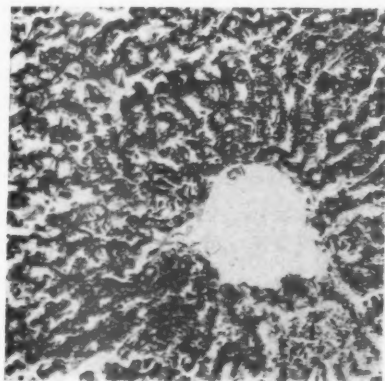


FIGURE XII. From rat in which 1.5 grammes of sulphapyridine had been inserted in the peritoneal cavity the previous day. Showing fatty degeneration of the liver cells, especially around the central vein.

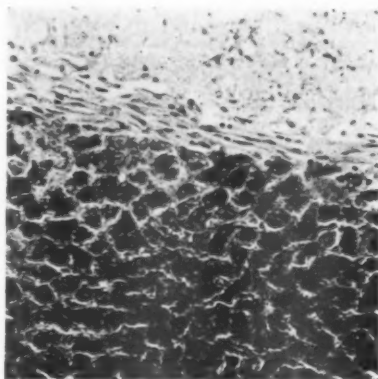


FIGURE XIII. From rat in which 1.0 gramme of sulphapyridine had been inserted in the peritoneal cavity six days previously. Showing the surface of the liver with a few fibroblasts in the capsule on which crystals of the drug were placed. The liver cells do not appear to have been affected by the drug.

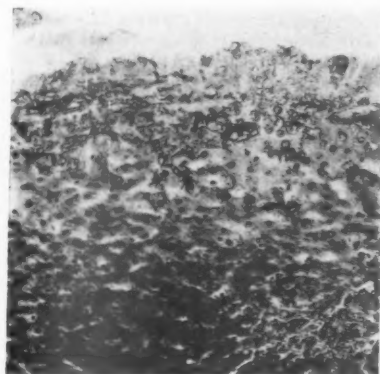


FIGURE XIV. From rat in which 2.0 grammes of sulphathiazole were inserted in the peritoneal cavity the previous day. Showing the crystals of the drug on the surface of the liver, the superficial cells of which stained poorly and showed cloudy swelling. This local effect was probably due to the sulphathiazole diffusing into the liver, and contrasts with the absence of any effect on the liver cells beneath adherent sulphapyridine (Figure XIII).

Several of the rats of Experiment IV became sluggish in their movements and dyspnoeic within twenty-four hours of the operation and others died. The blood sulphonamide levels in these animals were very high (Table II). In the rats in which this happened the drug concerned was sulphathiazole in seven, sulphapyridine in three, and sulphanilamide in three. The livers of some of these animals were hyperaemic, but this was not a constant feature.

In three rats in which 3.0 grammes of sulphapyridine were inserted, death occurred from intestinal obstruction, due to the mass of the drug and omentum; but in no rat in which sulphathiazole or sulphanilamide was implanted, was death due to intestinal obstruction.

Sections were prepared from the kidneys and pancreas of fifteen of the rats of this experiment, but they revealed no abnormality.

Most of the livers from rats in which sulphapyridine was implanted in the peritoneal cavity, showed cloudy swelling or some shrinking of the liver columns; and in the livers of two fatty degeneration occurred, especially around the central veins (Figure XII). Apart from a few fibroblasts in the capsule, there was no reaction to powdered sulphapyridine on the surface of the liver (Figure XIII). In the liver of

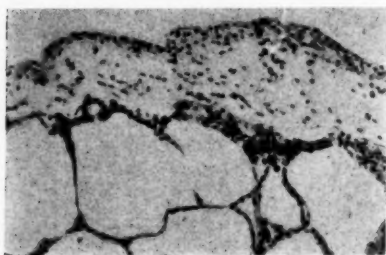


FIGURE XV. From rat in which 0.25 gramme of sulphathiazole had been inserted in the pleural cavity fourteen days previously. Showing the subpleural edema and increased cellularity.

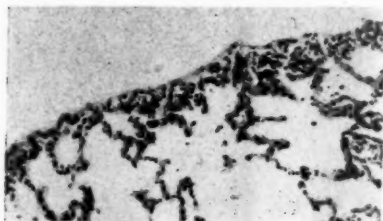


FIGURE XVI. From rat in which 0.5 gramme of sulphapyridine had been inserted in the pleural cavity six days previously. Showing partial pulmonary collapse and some increase in subpleural cells.

one rat in which sulphanilamide was inserted in the peritoneal cavity, fatty degeneration was present. In another rat there were cloudy swelling and a decreased staining ability of the cells beneath crystals of sulphathiazole on the surface of the liver (Figure XIV). With these two exceptions, very little change was observed in the sections (stained by hæmatoxylin-eosin) of the livers of the other rats in which sulphathiazole or sulphanilamide was inserted.

Sections of the livers stained with Best's mucicarmine stain were examined; a slight decrease in glycogen was found in sections from rats in which sulphanilamide was inserted in the peritoneal cavity; but in livers from animals in which sulphapyridine or sulphathiazole was inserted, the glycogen content was normal.

Experiment V.—Experiment V consisted in the insertion in the pleural cavity of 0.25 gramme of sulphapyridine (five rats, killed on the first, fifth, eleventh and twenty-first days), sulphathiazole (four rats; one died within forty-eight hours of operation, three killed on the first, second and eleventh days) and sulphanilamide (four rats; one died within forty-eight hours of operation, three killed on the first, first and eleventh days). In two rats the pleural cavity was opened and closed without the insertion of any drug. These were killed on the fifth and eleventh days. The lung on the side of the operation was removed for sectioning.



FIGURE XVII. From rat in which 0.15 gramme of sulphapyridine had been implanted on the surface of the brain eleven days previously. Showing a definite meningeal reaction to the drug.

The subpleural tissue was slightly oedematous and infiltrated with lymphocytes in rats in which sulphathiazole or sulphapyridine was inserted (Figures XV and XVI), but appeared normal with sulphanilamide. With the three sulphonamides, early bronchopneumonic changes were seen in the lungs.

Sulphapyridine had almost completely disappeared from the pleural cavity by the fifteenth day and sulphathiazole by the second day; but sulphanilamide was absorbed within twenty-four hours.

In Table II the high blood sulphonamide levels one or two days after the implantation of sulphathiazole or sulphanilamide in the

pleural cavity are shown, as is the disappearance of the drugs from the blood of these rats within eleven days. With sulphapyridine a blood level of only 1.6 milligrammes *per centum* was reached in six days. Two of the rats in which sulphanilamide was inserted, had blood levels of 46 and 58 milligrammes *per centum* after one day; but in the other rat in which sulphanilamide was inserted, the blood did not contain any of the drug by the eleventh day.

TABLE II.

Rats in which Blood Sulphonamide Estimations were Performed.

Days after Operation.	Region in which Drug was Inserted.	Amount of Drug. (Grammes.)	Blood Level. (Milligrammes <i>per centum</i> .)
<i>Sulphapyridine :</i>			
5	Skin.	0.5	0.2
13	Skin.	0.5	1.3
4	Muscle.	0.25	1.6
6	Muscle.	0.25	0.7
14	Muscle.	0.25	0.1
11	Meninges.	0.15	0
1	Pleural cavity.	0.25	1.4
5	Pleural cavity.	0.25	1.3
5	Pleural cavity.	0.25	1.6
11	Pleural cavity.	0.25	0
21	Pleural cavity.	0.25	0
1	Peritoneal cavity.	1.5	44.8
1	Peritoneal cavity.	2.0	38.0
1	Peritoneal cavity.	2.0	43.0
1	Peritoneal cavity.	3.0	3.4
1	Peritoneal cavity.	3.0	2.1
5	Peritoneal cavity.	0.5	4.0
6	Peritoneal cavity.	1.0	19.9
11	Peritoneal cavity.	0.5	0
11	Peritoneal cavity.	2.0	1.4
13	Peritoneal cavity.	0.5	1.3
14	Peritoneal cavity.	0.5	0.8
14	Peritoneal cavity.	1.0	1.1
17	Peritoneal cavity.	0.5	0
18	Peritoneal cavity.	0.5	0
20	Peritoneal cavity.	2.0	0.7
22	Peritoneal cavity.	1.0	0
29	Peritoneal cavity.	2.0	0.5
32	Peritoneal cavity.	1.0	0
<i>Sulphathiazole :</i>			
2	Skin.	0.5	1.9
10	Skin.	0.5	3.1
14	Skin.	0.5	0.5
1	Pleural cavity.	0.25	48.0
2	Pleural cavity.	0.25	28.0
11	Pleural cavity.	0.25	0
1	Peritoneal cavity.	0.25	36.0
1	Peritoneal cavity.	0.25	38.0
1	Peritoneal cavity.	0.5	52.0
1	Peritoneal cavity.	0.5	68.0
1	Peritoneal cavity.	0.5	76.0
1	Peritoneal cavity.	1.0	97.0
1	Peritoneal cavity.	2.0	72.0
10	Peritoneal cavity.	0.25	0.1
<i>Sulphanilamide :</i>			
2	Skin.	0.5	1.4
1	Muscle.	0.25	70.0
21	Muscle.	0.25	0.1
1	Pleural cavity.	0.25	46.0
1	Pleural cavity.	0.25	58.0
11	Pleural cavity.	0.25	0
1	Peritoneal cavity.	0.5	39.0
1	Peritoneal cavity.	0.5	49.0
1	Peritoneal cavity.	0.5	63.0
15	Peritoneal cavity.	0.5	0.4
21	Peritoneal cavity.	0.25	0.1

Experiment VI.—In Experiment VI the skulls of two rats were trephined and 0.15 gramme of sulphapyridine was placed on the surface of the brain of one; both wounds were then closed. A much greater meningeal reaction was present in the former rat (Figure XVII) than in the control.

Experiment VII.—In Experiment VII the knee joint was opened in two rats; 0.25 gramme of sulphapyridine was inserted in one and then both were closed. The only changes produced were traumatic.

Previously it had been shown in a small series of cases of infections treated with the sulphonamides that the only accompanying changes in the bone marrow were attributable to the infections (Wilson⁽⁵⁹⁾). Clinical reports of the changes in the blood due to sulphonamide administration continue to appear,⁽⁴²⁾ but usually without descriptions of the marrow.

In eleven of the rats in which sulphapyridine was inserted, the blood was examined before the operation, and the blood and bone marrow were examined immediately before death. Blood and marrow examinations were performed on ten normal rats as controls. The results of these examinations are contained in Table III; and it may be seen that in these few animals

TABLE III.

Summary of Mean Blood and Marrow Counts of Ten Control Rats and of Eleven Rats in which 0.5 Gramme of Sulphapyridine was Implanted in the Tissues.

Observation.	Controls.	Before Implantation.	After Implantation.
<i>Blood :</i>			
Hæmoglobin (grammes per centum)	15.8	15.0	14.8
Erythrocytes (millions per cubic millimetre)	8.9	8.5	7.9
Reticulocytes (percentage)	1.0	1.0	1.0
Platelets (thousands per cubic millimetre)	367.0	407.0	433.0
Leucocytes (thousands per cubic millimetre)	10.4	7.9	9.1
Neutrophile cells (percentage)	18.1	19.6	22.9
Metamyelocytes (percentage)	3.5	3.5	3.4
Eosinophile cells (percentage)	0.8	1.1	0.6
Monocytes (percentage)	0.2	0.8	0.2
Lymphocytes (percentage)	77.4	75.0	72.9
<i>Bone Marrow :</i>			
Neutrophile cells (percentage)	1.2	—	0.6
Metamyelocytes (percentage)	42.6	—	47.4
Myelocytes (percentage)	5.8	—	4.8
Premyelocytes (percentage)	0.8	—	0.4
Myeloblasts (percentage)	0.4	—	0.4
Eosinophile cells (percentage)	4.8	—	2.8
Basophile cells (percentage)	0.4	—	0.4
Plasma cells (percentage)	2.8	—	2.0
Lymphocytes (percentage)	0.4	—	0.6
Normoblasts (percentage)	38.8	—	39.2
Late erythroblasts (percentage)	1.0	—	0.6
Mitotic figures (percentage)	0.4	—	0.6
Megakaryocytes (percentage)	0.6	—	0.2

significant changes in the blood or marrow were not produced by the local implantation of 0.5 gramme of sulphapyridine. Nor were significant differences seen in the sections of the marrow.

Some of my experiments are incomplete—for instance, those in which the drugs were placed in joints or on the brain. It was not possible to include a study of the effects on nerves (except those which were included by chance in the wounds and in which no abnormality was found), conjunctivæ or tendons.

DISCUSSION.

Compared with the control rats, and except in one rat in which infection developed after the sulphanilamide was absorbed, any infection in the wounds in which the sulphonamides had been inserted, was minimal. That infection developed in this rat showed the necessity for the prevention of wound contamination after the drug is absorbed. These experiments are in accord with the clinical results.

From the results obtained in these experiments, suggestions may be made for the clinical use of these drugs.

Sulphapyridine is soon walled off from the wound and is therefore unsuitable for local implantation. This encapsulation by granulation tissue occurs to a less extent with sulphathiazole, and not at all with sulphanilamide. Sulphanilamide is therefore to be preferred for local use in wounds; but when delay in absorption is desired or when the organisms of the wound are less susceptible to sulphanilamide, then a mixture of sulphanilamide and sulphathiazole may be advantageous.

No toxic changes due to the drugs were seen in the muscles. Similar responses to the drugs and similar rates of absorption were found with the implantation of the drugs in the muscles and in the subcutaneous tissues. Glynn⁽¹⁵⁾ reported the absence in the rabbit of foreign body giant celled reaction to the sulphonamides; but in the rat sulphapyridine, sulphathiazole and sulphanilamide all excited slight giant celled responses.

Following the intraperitoneal use of sulphanilamide six out of twenty-five of Jackson's patients⁽²³⁾ developed a definite icterus. This author found during the absorptive stage that the blood sulphanilamide level of his patients was 30% to 40% higher in the portal blood than in the jugular blood. Spink, Bergh and Jermsta⁽⁵⁰⁾ have shown that sulphanilamides and sulphapyridine are excreted in the bile after oral administration. Berger and Applebaum⁽¹⁾ and other authors have reported cases of toxic hepatitis associated with the exhibition of sulphanilamide. Davis, Harris and Schmeisser⁽¹²⁾ produced toxic changes in the livers of their rats by repeated subcutaneous injections of sulphanilamide.

None of our patients in whom sulphonamides were implanted became jaundiced; but because of these reports, special attention was paid to the livers of the rats. In three of the thirty-six rats in which sulphonamides were implanted in the peritoneal cavity, fatty degeneration of the liver occurred. In two of them 3.0 grammes of sulphapyridine had been implanted in the peritoneal cavity the previous day, and about half of the drug had been absorbed. Three grammes in a 250-gramme rat are equivalent to 76.5 grammes per stone of body weight. This large dose did not always produce fatty degeneration. In the other rat in which fatty degeneration occurred, 0.5 gramme (that is, 12.7 grammes per stone) of sulphanilamide had been inserted twenty-one days previously. Cloudy swelling of the liver cells of the rats was sometimes caused by this latter dose of sulphanilamide. Clinically this is probably of no importance, for 2.0 grammes per stone is recommended as the maximum amount of drug to be used in a wound. Apart from that, owing to the frequency with which sulphapyridine was shut off from the peritoneal cavity by omentum, it is unsuitable for intraperitoneal use. Except for cloudy swelling of a few surface cells of the liver beneath adherent sulphathiazole crystals, this drug did not produce any other local peritoneal reaction. However, the rapidity with which this drug may be absorbed from the peritoneum, as indicated by the high blood sulphathiazole levels in the rats (Table II), suggests that the amount of this drug inserted in the peritoneal cavity should not be unnecessarily large. Such also applies to the intraperitoneal use of sulphanilamide.

The rates of absorption of the sulphonamides from the pleural cavity were of the same order as from the peritoneal cavity. The early bronchopneumonic changes in the lungs were probably due to the thoracotomy; but because of the pleural reaction, the encapsulation of sulphapyridine and the rapid absorption of sulphathiazole and sulphanilamide, the local implantation of these drugs in the pleural cavity has very little place in the treatment of diffuse pleural infections. Other routes of administration will produce effective sulphonamide levels in the pleural fluid. As in other wounds,

the prophylactic use of sulphanilamide in thoracotomy wounds reduces the incidence and severity of infections.

SUMMARY.

As judged by a clinical trial in more than one hundred patients, the local application of sulphanilamide to wounds, ulcers, burns and skin grafts is often of considerable value.

Sulphapyridine, sulphathiazole and sulphanilamide were implanted in the tissues and body cavities of one hundred rats. Seventeen rats were used as controls. From these experiments it may be concluded that only extremely large amounts of these drugs produce deleterious effects on the tissues, and that lesser amounts do not inhibit reparative processes. Because solid sulphapyridine is rapidly walled off by granulation tissue, this drug is much less suitable for local application than sulphanilamide. Sulphathiazole, having a solubility intermediate between those of sulphanilamide and of sulphapyridine and only rarely being walled off by granulation tissue, is indicated for local application when delay in absorption is desirable or when the special effects of sulphathiazole are necessary. Local chemotherapy is not advisable for the treatment of diffuse pleural or peritoneal infections. - No significant differences were found in the blood or bone marrow of a small series of rats in which sulphapyridine was implanted.

ACKNOWLEDGEMENTS.

I wish to express my gratitude to Mr. Hugh R. G. Poate, Director of Post-Graduate Surgery, Prince Henry Hospital, and Mr. R. J. W. Malcolm, Chief Resident Surgeon, for their interest in the clinical aspects of this method of treatment; to Dr. F. B. Byrom, Director of Post-Graduate Pathology, for making the facilities of his department available to me; to Mr. R. Fisher, biochemist, for the blood sulphonamide estimations; and to Mr. F. Wilkins and Mr. C. Strumpel, technicians, for their help with the preparation of the illustrations and sections.

REFERENCES.

- ⁽¹⁾ S. S. Berger and H. S. Applebaum: "Toxic Hepatitis due to Sulfanilamide", *Journal of Laboratory and Clinical Medicine*, Volume xxvi, February, 1941, page 785.
- ⁽²⁾ B. J. Bickford: "Local Sulphanilamide for Penetrating Wounds of Joints", *British Medical Journal*, April 26, 1941, page 627.
- ⁽³⁾ N. J. Bonnin and F. Fenner: "Local Implantation of Sulphanilamide for the Prevention and Treatment of Gas Gangrene in Heavily Contaminated Wounds: A Suggested Treatment for War Wounds", *The Medical Journal of Australia*, February 1, 1941, page 134.
- ⁽⁴⁾ E. M. Bricker and E. A. Graham: "The Inhibitory Effect of Sulfanilamide in Wound Healing", *The Journal of the American Medical Association*, Volume cxii, 1939, page 2593.
- ⁽⁵⁾ J. L. Brown: "Prontosil by the Intrapleural Route: Two Cases of Streptococcal Empyema", *British Medical Journal*, June 5, 1937, page 1157.
- ⁽⁶⁾ St. J. D. Buxton: "Sulphanilamide and Wound Infections", *British Medical Journal*, December 7, 1940, page 802.
- ⁽⁷⁾ W. C. Campbell and H. Smith: "Sulfanilamide and Internal Fixation in the Treatment of Compound Fractures", *Journal of Bone and Joint Surgery*, Volume xxii, 1940, page 959.
- ⁽⁸⁾ J. H. Childrey: "Use of Sulfanilamide Locally for Sinus Infections", *Archives of Otolaryngology*, Volume xxix, 1939, page 986.
- ⁽⁹⁾ L. Colebrook: "Treatment of War Wounds by Sulphonamide Packs", *The Lancet*, July 27, 1940, page 113.
- ⁽¹⁰⁾ L. Colebrook and A. E. Francis: "Elimination of Streptococci from Superficial Wounds by Sulphanilamide Powder", *The Lancet*, March 1, 1941, page 271.
- ⁽¹¹⁾ C. Crile: "The Local Use of the Sulfonamide Drugs", *Cleveland Clinic Quarterly*, Volume viii, July, 1941, page 149.

- (12) H. A. Davis, L. C. Harris and H. C. Schmeisser: "The Toxic Effects of Sulfanilamide upon Tissues of Rats", *Journal of Laboratory and Clinical Medicine*, Volume xxv, September, 1940, page 1263.
- (13) S. Eisenhammer: "Sulphonamides Applied Locally", *The Lancet*, December 14, 1940, page 760.
- (14) A. E. Francis: "Discussion on Chemotherapy and Wound Infections", *Proceedings of the Royal Society of Medicine*, Volume xxxiv, April, 1941, page 337.
- (15) L. E. Glynn: "The Effects of Sulphanilamide, Sulphathiazole and Sulphapyridine on the Development of Granulation Tissue and their Toxic Action on Striped Muscle", *The Journal of Pathology and Bacteriology*, Volume liii, September, 1941, page 183.
- (16) J. Gordon and J. W. McLeod: "Relative Value of Sulphonamides and Antisera in Experimental Gas Gangrene", *The Lancet*, March 29, 1941, page 407.
- (17) F. Hawking: "Prevention of Gas Gangrene Infections in Experimental Wounds by Local Application of Sulphonamide Compounds and by Sera", *British Medical Journal*, February 22, 1941, page 263.
- (18) F. Hawking: "Local Concentration of Sulphonamide Compounds Inserted into Wounds", *The Lancet*, June 21, 1941, page 786.
- (19) F. Hawking: "Methods for the Local Application of Sulphanilamide", *British Medical Journal*, November 15, 1941, page 685.
- (20) F. Hawking and J. E. Piercy: "Blood Concentrations Following Local Application of Sulphonamide Compounds to Wounds", *British Medical Journal*, April 5, 1941, page 511.
- (21) D. H. Hooker and C. R. Lam: "Absorption of Sulfanilamide from Burned Surfaces", *Surgery*, Volume ix, April, 1941, page 534.
- (22) R. V. Hudson, R. Smith and F. R. Selbie: "The Prognosis of Acute Intestinal Obstruction: Experiments with Intraperitoneal Sulphanilamide", *The Lancet*, April 5, 1941, page 438.
- (23) H. C. Jackson: "Intraperitoneal Sulfanilamide", *Annals of Surgery*, Volume cxiii, June, 1941, page 1069.
- (24) F. Jacoby, P. B. Medawar and E. N. Willmer: "The Toxicity of Sulphonamide Drugs to Cells in Vitro", *British Medical Journal*, August 2, 1941, page 149.
- (25) J. S. Jeffrey: "Treatment of War Wounds in France", *Edinburgh Medical Journal*, Volume xlvii, November, 1940, page 727.
- (26) N. K. Jensen, L. V. Johnsrud and M. C. Nelson: "The Local Implantation of Sulfanilamide in Compound Fractures", *Surgery*, Volume vi, July, 1939, page 1.
- (27) I. Lloyd Johnstone: "Sulphonamide Treatment of Hypopyon Ulcer of the Cornea", *British Medical Journal*, June 14, 1941, page 887.
- (28) R. V. Jones: "Local Chemotherapy as a Curative Measure", *British Medical Journal*, August 23, 1941, page 266.
- (29) J. A. Key and T. H. Burford: "The Local Implantation of Sulphanilamide in Compound Fractures: Its Effect on Healing", *Southern Medical Journal*, Volume xxxiii, 1940, page 449.
- (30) J. A. Key and T. H. Burford: "The Prophylactic Implantation of Sulphanilamide in Clean Operative Wounds for the Reduction of Post-Operative Infections", *Surgery, Gynecology and Obstetrics*, Volume lxxiii, September, 1941, page 324.
- (31) J. A. Key and C. J. Frankel: "The Local Use of Sulfanilamide, Sulfapyridine and Sulfamethylthiazole", *Annals of Surgery*, Volume cxiii, February, 1941, page 284.
- (32) J. A. Key, C. J. Frankel and T. H. Burford: "The Local Use of Sulfanilamide in Various Tissues", *The Journal of Bone and Joint Surgery*, Volume xxii, 1940, page 952.
- (33) A. C. King: "Treatment of Open Wounds by the Sulphanilamide Pack", *British Medical Journal*, February 15, 1941, page 231.
- (34) R. Legroux: "Chimio-prévention de l'infection bactérienne des plaies de guerre", *Mémoires de l'Académie de chirurgie*, Volume lxvi, April, 1940, page 415.
- (35) J. S. Lockwood: "Sulphonamide Therapy as an Aid to Surgery", *Surgery, Gynecology and Obstetrics*, Volume lxxii, February, 1941, page 306.
- (36) J. S. Lockwood: "Sulfanilamide and its Derivatives in Surgical Infections", *Surgery*, Volume x, September, 1941, page 493.
- (37) L. W. Long and J. G. Dees: "The Local Use of Sulfanilamide", *Surgery*, Volume ix, June, 1941, page 878.
- (38) J. Millet: "The Intrathecal Use of Prontosil Soluble", *The Journal of the American Medical Association*, Volume cix, 1937, page 2139.
- (39) R. Mowlen: "Discussion on Chemotherapy and Wound Infections", *Proceedings of the Royal Society of Medicine*, Volume xxxiv, April, 1941, page 337.
- (40) F. Nitti: "Elimination of p-Aminobenzene Sulphonamide Applied to Wounds: Protective Antimicrobial Action", *La presse médicale*, Volume xlvii, 1940, page 1577.

- (41) Hugh R. G. Poate: "Some Considerations in the Treatment of Wounds", *The Medical Journal of Australia*, June 28, 1941, page 773.
- (42) S. S. Rinkoff and M. Spring: "Toxic Depression of the Myeloid Elements Following Therapy with the Sulphonamides: Report of Eight Cases", *Annals of Internal Medicine*, Volume xv, July, 1941, page 89.
- (43) J. M. Robson and A. B. Wallace: "Use of a Glycerin-Sulphonamide Paste ('Euglamide') in Treatment of Burns", *British Medical Journal*, March 29, 1941, page 469.
- (44) S. Rosenburg and N. W. Wall: "The Treatment of Diffuse Peritonitis by the Direct Intraperitoneal Introduction of Sulfanilamide", *Surgery, Gynecology and Obstetrics*, Volume lxxii, March, 1941, page 568.
- (45) D. S. Russell and M. A. Falconer: "Local Effects of Sulphonamides on the Rabbit's Brain", *The Lancet*, July 27, 1940, page 100.
- (46) W. M. Sams and L. Capland: "Topical Treatment with Sulfathiazole", *Archives of Dermatology and Syphilology*, Volume xlv, August, 1941, page 226.
- (47) L. Schneider: "The Local Use of Sulfanilamide Powder and Hydrogen Peroxide in Wound Infection", *The American Journal of the Medical Sciences*, Volume cci, February, 1941, page 208.
- (48) J. A. Smith: "Local Treatment with Prontosil Soluble", *British Medical Journal*, June 22, 1940, page 1016.
- (49) W. W. Spink: "The Bactericidal Effect of Sulfanilamide upon Pathogenic and Non-Pathogenic Staphylococci", *Journal of Immunology*, Volume xxxvii, 1939, page 345.
- (50) W. W. Spink, G. S. Bergh and J. Jermsta: "The Excretion of Sulfanilamide and Sulfapyridine in Human Bile", *Surgery*, Volume ix, June, 1941, page 853.
- (51) W. G. Stuck, E. A. Maxwell and R. N. O. Monsalvo: "Crystalline Sulphanilamide in Compound Fractures", *Texas State Journal of Medicine*, Volume v, July, 1940, page 225.
- (52) M. Taffel and S. C. Harvey: "Effect of Sulfanilamide on Wound Healing", *Proceedings of the Society for Experimental Biology and Medicine*, Volume xlv, 1940, page 647.
- (53) A. M. Thomas: "Treatment of Diphtheria Carriers with Sulphathiazole Snuff", *British Medical Journal*, November 15, 1941, page 687.
- (54) J. E. Thompson, J. A. Brabson and J. M. Walker: "The Intra-Abdominal Application of Sulfanilamide in Acute Appendicitis", *Surgery, Gynecology and Obstetrics*, Volume lxxii, April, 1941, page 722.
- (55) T. D. Throckmorton: "The Peritoneal Response to Powdered Sulfonamide Compounds: An Experimental Study", *Proceedings of the Staff Meetings of the Mayo Clinic*, Volume xvi, July 2, 1941, page 423.
- (56) R. L. Varco, L. J. Hay and B. Stevens: "The Value of the Local Implantation of Crystalline Sulfanilamide about Gastrointestinal Anastomoses in Dogs", *Surgery*, Volume ix, June, 1941, page 863.
- (57) J. de Vidas and A. C. McEachern: "A Biochemical Investigation of the Tannic Acid and Sulphanilamide Treatment of Burns", *The Medical Journal of Australia*, October 25, 1941, page 470.
- (58) E. N. Wardle: "A Penetrating Injury of the Knee-Joint", *British Medical Journal*, November 30, 1940, page 743.
- (59) T. E. Wilson: "Bone Marrow Changes in Acute Infections and the Effects of Sulphonamides on the Marrow", *The Medical Journal of Australia*, March 1, 1941, page 257.
- (60) D. D. Woods: "The Relation of p-Aminobenzoic Acid to the Mechanism of the Action of Sulphanilamide", *The British Journal of Experimental Pathology*, Volume xxi, 1940, page 74.

INFECTIVE COMPLICATIONS OF HEAD BATTLE CASUALTIES.¹

By DOUGLAS MILLER,

Officer Commanding Neurosurgical Unit, Australian Imperial Force.

A PERIOD recently spent as Officer Commanding British Neurosurgical Centre for Middle East Forces gave the writer an opportunity of observing a remarkable series of wounds sustained in the Western Desert campaign. The peculiar conditions of this campaign were responsible for a high proportion of unusual features in the injuries which reached the base. The factor of delay in obtaining proper treatment was important. It was a campaign of rapidly moving and often disorganized units, and wounded were often lost for days or else taken prisoner for varying periods during their evacuation. Undoubtedly the early administration of sulphonamides solved many bizarre brain injuries in patients who otherwise could not have survived.

Fifty patients with open head wounds reached the neurosurgical centre after the first battle. Some of these had been fortunate in receiving early and proper treatment at forward operating centres, and the majority of the wounds of these patients had healed by first intention. Over 25% of the whole series of wounds were, however, infected. Many of these infections were in the circumstances unavoidable, while other wounded could have been better handled. Though it is not the purpose of this report to deal with the early treatment of head wounds, it should be emphasized that the complications of infection are to a large extent avoidable by good primary treatment, which is applicable much later to head wounds than to wounds elsewhere. Whereas an arbitrary limit of about ten hours is put to the period that may elapse before the excision of wounds generally, it is undoubtedly right to prolong this period to forty-eight hours or longer in head injuries. Surgeons in forward units should endeavour to use this greater time in getting their patients with head injuries to some centre where they can be skilfully handled in suitable surroundings. It is much better for the forward unit to place a clean dressing on a head wound and then evacuate the patient, even for a journey of twenty-four hours or longer, than to embark on operative interference with insufficient experience and equipment or capacity for nursing the patient. This last point, so important in regard to all severe wounds, is particularly to be emphasized in head wounds. The patients travel better before than after surgical intervention.

One case demonstrated a satisfactory compromise in this regard.

A Royal Army Service Corps driver was blown up by a land mine and sustained a very extensive compound fracture of the left frontal bone. In effect, a large osteoplastic flap had been thrown back from the mid-line to the mid-temporal region on the left side. The bone detached included the superior margin and roof of the orbit. Treated at a casualty clearing station shortly after the accident, he was given a transfusion, the wound was cleaned, bleeding was stopped, and a large loose fragment of bone was removed. (See Figure I.) The damaged brain was not interfered with and the skin flap and attached bone were wrapped in "Vaseline" gauze and the patient evacuated to the neurosurgical centre, where he arrived five days later. The large open wound was found to be clean and, under anaesthesia, the pulped brain was carefully irrigated and the wound closed by accurate suture, except at the inner angle, where

¹ Accepted for publication on May 6, 1942.

some skin loss necessitated leaving a small area of brain uncovered. The skin flap healed by first intention and the small *fungus cerebri* quickly receded and granulated over.

Though this wound would have been better sutured in the first place, the surgeon, not feeling competent to deal with the damaged brain, did a logical and, as it happened, entirely successful thing.

Illustrative of the possibility of performing late a thorough cleansing and suture was the case of a patient admitted with a temporal wound which was clean and almost healed.

The patient had been injured in battle, sustaining a severe compound fracture with open brain injury. His only treatment for the first four days had been a field dressing. He then reached a casualty clearing station, where his wound was excised, damaged bone was removed and pulped brain gently irrigated out of the wound, which was then sutured with drainage. The tube was later removed by us.

This rather extreme example serves to emphasize the length of time after which it was possible to apply proper primary treatment. Such cases caused but few late problems.

Infection is the result of leaving wounds open, and the application of the so-called Trueta principles to head wounds leads inevitably to disaster. These

infective complications followed all forms of wounds.



FIGURE I.

SCALP WOUNDS.

Several scalp wounds had been left open and packed with sulphonamide powder or "Vaseline" gauze. They all became infected, healed very slowly and prolonged the patient's convalescence by weeks. One such wound was complicated by an extradural abscess.

A young tank officer sustained a superficial wound in the left frontal region. Some days later he reached the base with an open infected scalp wound. His cerebration was very slow, but he was sensible and had no neurological signs. He remained in this condition for a fortnight, when he suddenly had a rigor and his temperature rose to 104° F. The following day it was 103° F. He felt well and had no signs. An exploratory burr hole was made through rather devitalized bone in the floor of his wound. A small fissured fracture was noted in the bone, and an extradural abscess containing about an ounce of pus was evacuated. His general mental condition showed immediate improvement and drainage soon ceased.

In this case a long period of hospital care resulted from poor primary treatment.

Certain counsels of perfection concerning the early treatment of scalp wounds have been promulgated, and the obvious difficulty in most cases of carrying these out may result in a policy of *laissez faire*. Though it may be very desirable after excision of a scalp wound to suture it accurately with two layers of black silk, the fundamental thing is to explore, clean and close the wound, and for this silkworm gut is always at hand, more easily used and quite satisfactory.

INFECTION OF THE SKULL.

There were several cases of infection of the skull much resembling one another. Most of them appeared to be small tangential wounds, with no general or local brain injury. After varying periods the patients arrived at the base with small infected and partially healed wounds, some of which had been sutured, while others had not. These wounds all had a little purulent discharge, and a probe could detect underlying bare bone. X-ray photographs showed small comminuted fractures with shallow indriving of fragments. The patients complained of localized headache and were generally below par.

Operative treatment consisted of opening the wounds sufficiently to allow the insertion of a self-retaining mastoid retractor, the fracture thus being exposed. Mostly these were no larger than a sixpenny piece, and small bone fragments were indriven and incarcerated beneath the edge of the defect. It was necessary to cut away a little of this edge in order to remove the fragments. There were sometimes hairs or small metallic foreign bodies with the bone and always a little pus. The wounds were closed with drainage and mostly healed quickly. It was always noticed that after operation the general condition of these patients greatly improved, and the localized headache was relieved.

In these cases again it would be pointed out that proper early treatment with wound excision and removal of bone fragments would save many weeks of invalidism.



FIGURE IIA. Foreign body with no infection.

INFECTION OF THE BRAIN.

All infected wounds of the brain were associated with retained foreign bodies, which were of three types: the most common were indriven bone fragments, the others metallic foreign bodies or, in one case, a gauze plug introduced by some misguided forward operator. It is well to note that neither bone fragments nor metallic foreign bodies are necessarily associated with infection. X-ray photographs of several satisfactorily healed wounds showed considerable quantities of bone and metallic foreign bodies in the brain. In fact, only two such patients who had been properly treated, later developed infective complications. It is to be learnt from this observation that deeply indriven foreign bodies are best left alone, and primary surgical treatment should be concentrated on the wound and the superficial part of the injured brain. The fruits of infection were abscesses and infected sinuses leading to foreign bodies. All these wounds appeared to have become infected by way of a persisting communication with an improperly treated external wound. There is no need to dilate on the obvious stupidity of packing gauze

into a brain, and it is not surprising that the patient treated in this way died very quickly of an encephalitic abscess with ventricular infection. (See Figure IIa.)

INFECTED SINUSES OF THE BRAIN.

There were five patients with open infected sinuses leading to foreign bodies, in all cases bone fragments, though metallic fragments were also present in two. These wounds all appeared to be the result of tangential injury. The fragmented bone appears to have been blown in like a spray and penetrates to a considerable depth. (See Figure IIb.) The majority of these patients suffered no total brain injury at the moment of the accident. They could recount the event in detail, and in several instances had been able to carry on their job.



FIGURE IIb.

One tank officer felt a hit on the back of his head and became aware of an intense bright light "like the sun", the result of direct stimulus to the visual cortex.

Another young trooper was aware of being hit on the side of the head

and immediately his opposite arm became powerless. He continued to fight for some hours.

The general condition of these patients on arrival at the base was good. They all had open wounds discharging pus, and a probe could be passed down a track until a foreign body was palpated. The length of the track was often

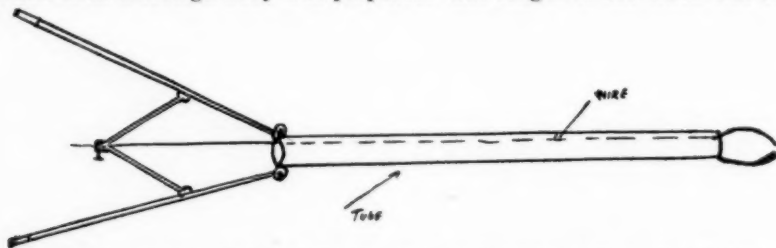


FIGURE III. Instrument devised for removing small foreign bodies. The working jaw is of strong wire. (Made by Captain Mustrade, Royal Army Medical Corps.)

disconcerting, as one became aware of how dangerously near to the ventricle the foreign body must be. Careful antero-posterior and lateral X-ray photographs were invaluable in enabling an accurate appreciation of the state of affairs to be made. The removal of such foreign bodies, and it is an essential procedure, is not a simple matter. Blind groping with forceps would spread infection or possibly push the body forward into a ventricle. The bone

fragments become closely surrounded by granulation tissue and are not readily dislodged. The ordinary artery forceps type of jaw may tend to slip the foreign body forward, and one should choose forceps which close like sugar tongs at the tip first and, if possible, work through a long shaft. (See Figure III.)

The following case illustrates one method of overcoming difficulties.

A Royal Army Service Corps driver was admitted to hospital sixteen days after wounding. He had been hit on the head during battle and received his first treatment four days later at a casualty clearing station. The wound was in the right fronto-parietal region. A somewhat inept and unsuccessful attempt had been made at *débridement* and closure. On his admission to the neurosurgical centre there was a large infected wound with scalp loss and a considerable area of exposed bone beneath it. In the centre of the bone was a defect about the size of a two-shilling piece, through which thick yellow pus welled up. X-ray photograph showed a large bone fragment in the middle of the right hemisphere, with smaller fragments along the track. (See Figure IV.)

The external part of the wound was enlarged by cutting away a lot of exposed necrotic bone and small easily grasped fragments were removed from the track. A probe could be passed into the hemisphere for about five centimetres along a track which had soft and ill-defined walls. No attempt was made to grasp the large bone fragments, but a small capillary rubber tube was inserted into the track. A few days later a similar tube was inserted beside it, and for a fortnight gradually increasing sizes of tubes were introduced up to one, 1.5 centimetres in diameter. The bone fragment was then readily palpable and was becoming more superficial. By this time the track had developed a rough wall. Unluckily, the bone fragment was lying with a large flat surface facing upwards. With great gentleness, a three-pronged dilator was passed down the track and opened a little. The engrafting granulation tissue was separated from the fragment with endothermy, and after some difficulty one edge was tilted up and the fragment withdrawn by forceps. Even this procedure had its consequence, for three days later the patient developed intense photophobia and headache, some left-sided paresis and a left plantar extensor response. His cerebro-spinal fluid pressure was 250 millimetres and over 100 cells per cubic millimetre were present. After an intense course of "M & B 693" he completely recovered in ten days.

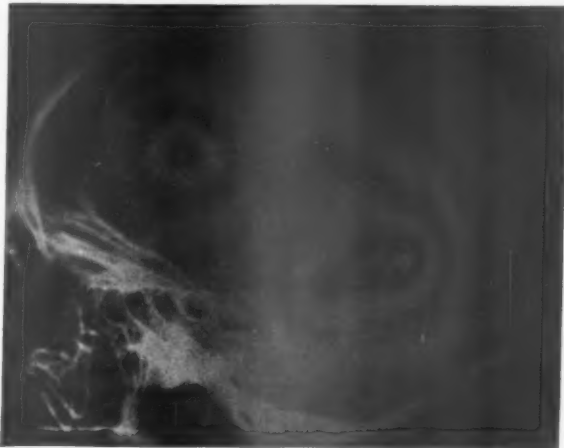


FIGURE IV. Showing bone fragment below and behind a skull defect.

X-ray photographs show how perilously close to the ventricle this fragment must have been and how carefully one had to approach it. In an attempt to remove such a fragment, the slightest slip could perforate the ventricle. It seems a logical procedure to await a firm reaction and prepare a way out.

FUNGUS CEREBRIS.

Five cases of *fungus cerebri* were encountered. All were the result of severe penetrating wounds which had had no early and at best very late treatment. Two of these were badly infected and had a most offensive smell. In these cases the surgeon must have some conception of the underlying pathology. The condition may be a deep abscess or a meningitic infection,

with resulting general œdema of the brain. Two of these cases were due to abscess and three to a meningitis.

Localizing signs, particularly if they are progressive, bespeak an abscess. X-ray disclosure of foreign bodies is also more than suggestive. A high cell and protein content in the cerebro-spinal fluid, though suggestive of a meningitis, does not exclude abscess. The most valuable observation is the response to treatment. The first essential in these cases is to improve the patient's condition and administer sulphanilamides. If the patients suffer from an uncomplicated meningitis, they will improve rapidly. In all cases we found it wise to concentrate first on the general condition, by giving rest, nourishment, "M & B 693" and by carrying out repeated lumbar puncture. As a rule, administration of "M & B 693" was regulated by repeated serum estimations and checked by leucocyte counts. A concentration of over seven milligrammes *per centum* was aimed at. Lumbar punctures aimed at keeping

the cerebro-spinal fluid pressure in the vicinity of normal. The very foul wounds responded better to iodoform than any other dressing tried. Patients exhausted by travelling and poor feeding improved rapidly with such treatment. Where there is reason to suspect abscess formation, the surgeon has to steel himself to explore what may be healthy brain through an infected area. My practice was to increase the size of the bone defect at one side of the fungus, treat the intact dura with the endotherm and then explore through this

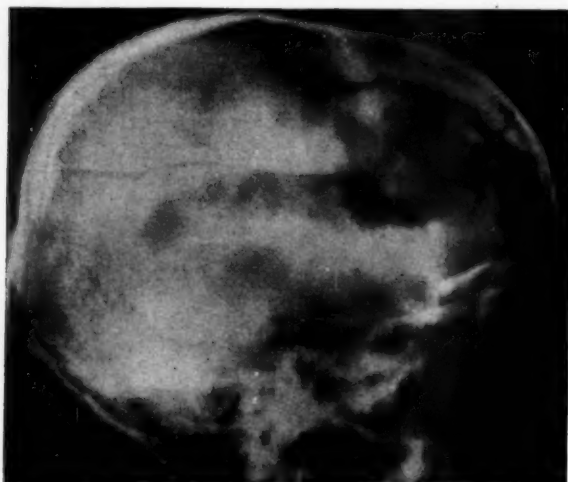


FIGURE V. Spontaneous ventriculogram.

shut-off area. Once there was a negative finding, and the patient came to no harm. When an abscess is found it is best drained at the side of the fungus, which in a few days rapidly recedes. The fungus itself is best dressed with an oily dressing and pads should be built up around it to protect it from injury. The naïve practice of shaving the fungus off has no basis of reason. Of our five patients the following one died.

Fungus with Spontaneous Rupture of a Ventricle.—A corporal was admitted without any early history and in an aphasic state. It appeared probable that he had been wounded about a fortnight previously. He had an infected wound with a considerable bone defect and a *fungus cerebri* in the left temporal region. His general condition was poor, and in addition to his aphasia he had a right hemiplegia. At first the fungus was not large, but it rapidly increased, and as he was very restless it became exceedingly difficult to protect it from injury. His cerebro-spinal fluid pressure was usually over 250 millimetres and contained over 100 cells per cubic millimetre. A week after his admission, cerebro-spinal fluid discharged from his wound. X-ray photographs taken at this time showed the ventricular system full of air. (See Figure V.) Both ventricles were very large, the left having a big diverticulum extending to the surface at the bone defect. The right lateral ventricle was displaced to the right. From now on his fungus receded, a cerebro-spinal fluid fistula continued to drain and his condition became worse. At the end of five days he died. Post-mortem examination revealed a ragged

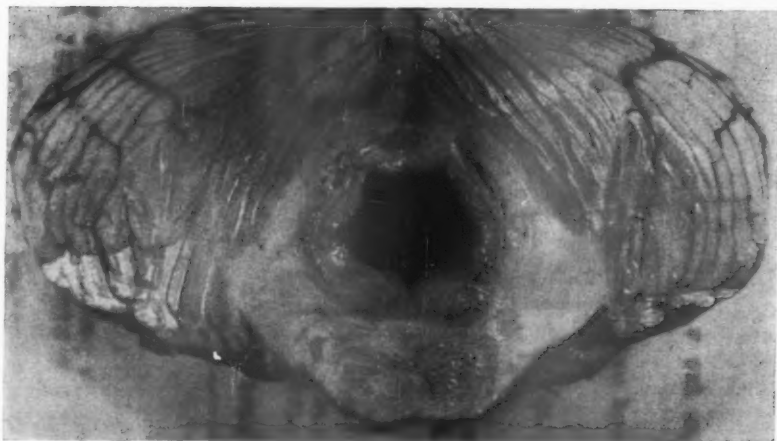


FIGURE VI. Showing dilated aqueduct of Sylvius.

septic track leading from the fungus to the anterior horn of the left ventricle. There was gross dilatation of the ventricular system, including the third and fourth ventricles and the aqueduct of Sylvius. There were a well marked ventriculitis and a basal meningitis from which staphylococci and streptococci were grown. Figure VI shows the dilated aqueduct of Sylvius and Figure VII shows a ragged track from the surface to the ventricle.

It seems likely that in this case a meningitic process started the ventricular dilatation which wandered towards the bone defect until spontaneous rupture occurred. This was followed by the fatal ventriculitis.

THE ABSCESSSES.

There were six abscesses—a high proportion compared with last war figures. Holmes had 2,357 head wounds with 37 abscesses; Vullier had 112 with one abscess; Rawling 775 with 19 abscesses; and Sargent and Holmes 610 with 12 abscesses.

The peculiar conditions already referred to are probably responsible for this high incidence. There were two deaths in these six cases, the total mortality among the fifty patients with head wounds being three.



FIGURE VII. Showing ragged track from surface to ventricle.

Some of the abscesses presented difficult problems, and are worthy of separate description.

Case I. Diffuse Encephalitic Abscess: Death.

A New Zealand Expeditionary Force private had been wounded by machine-gun fire twelve days before admission to hospital. He suffered no loss of consciousness and ran to a regimental aid post. Three days later he reached a casualty clearing station, where operative toilet of the wound was done and a "gauze plug" was inserted into damaged brain. Not until six days later was this plug removed at another casualty clearing station. The following day the patient complained of headache, and a purulent discharge from the wound was noted. On admission to hospital he was very drowsy, though cooperative if roused. There was an open infected wound the size of a shilling piece in the right posterior parietal area. Pus was exuding from this, and small bone fragments were palpable in the wound. He had a marked weakness of the left hand with complete astereognosis and loss of joint sense. His left leg was normal except for loss of joint sense. The following day he became comatose. On lumbar puncture the pressure was over 500 millimetres. Exploration with a brain cannula through the wound revealed soft brain at a depth of three centimetres, and about five cubic centimetres of pus and disintegrated brain tissue ran out. The following day he died.

Post-mortem examination showed that the right hemisphere was bulkier than the left, it was soft, and the convolutions were flattened. On section the greater part of the white matter was seen to have undergone softening with central abscess formation. There was a narrow tortuous slit-like abscess cavity extending longitudinally through the hemisphere for about five inches and communicating with the ventricle. The abscess walls were soft, yellow and hæmorrhagic.

This was the tragic end-result of bad early treatment. It is an example of ill-defined encephalitic abscess with ventricular infection.

Case II. Double Abscess: One Successfully Drained; Second Deep Abscess Later Ruptured into Ventricle: Death.

A Polish sergeant-major was admitted nearly a month after having sustained his head wound. He had a practically healed wound in the left temporo-parietal region, and was alert but aphasic and hemiplegic on the right side. Shortly after being wounded he had been in a similar state, but had improved until he suffered a relapse just before being transferred to the head centre. X-ray examination revealed an intracranial metallic foreign body near the sagittal plane in the left posterior parietal area.



FIGURE VIIIA. Showing second abscess and site of first abscess separated by brain tissue.

The wound was reopened and the skull defect enlarged. The dura was treated with the endotherm and exploration revealed an abscess at a depth of 1.5 centimetres. About one ounce of pus was evacuated and a tube inserted. The following day his condition was much improved, and he had much more power in the right side of his body. He was still aphasic, being able to understand German or Polish, but unable to speak either tongue. A week later, drainage had ceased and the tube was removed. His power had become normal, but his aphasia persisted and he could only speak jargon. He often became very excited and apparently had had nightmares. Thirteen days after drainage had ceased, his right hand became powerless again and he became drowsy. Exploration by brain cannula along and around the old track did not discover pus. The following day he had a fit and died.

Post-mortem examination revealed a clean well walled off track in the site of the old abscess. The whole of the white matter of the hemisphere was very swollen and œdematous. (See Figures VIIIA and VIIIB.) A small metallic foreign body was lying near the sagittal plane and it was surrounded by a small well walled off abscess which had discharged into the lateral ventricle. The two abscesses were separated by about one inch of apparently healthy brain.

A metallic foreign body had traversed the hemisphere almost to the mid-line. In its wake two separate abscesses had formed. Attempts to strike the deep abscess by the exploring cannula would be precluded by the proximity of the ventricle. If, however, a separate exploration had been made over the site of the foreign body, the second abscess would have been struck.



FIGURE VIIIb.

with a small *fungus cerebri* protruding about two centimetres above the surface and three centimetres in diameter.

He had a complete right homonymous hemianopia, right facial paresis, complete flaccid paralysis of the right arm and hand, with loss of sense of position of the fingers, and astereognosis. The right leg had very slight movement of the knee and ankle, with increase in deep tendon reflexes and loss of sense of position. X-ray examination revealed a large intracranial metallic foreign body in the left occipital region near the mid-line and about three centimetres from the surface. There was a bone defect in the left parietal region near the mid-line and some indriven bone fragments in the cortex beneath it. (See Figure IX.) His cerebro-spinal fluid pressure was 200 millimetres, with slight increase in cells and protein content.

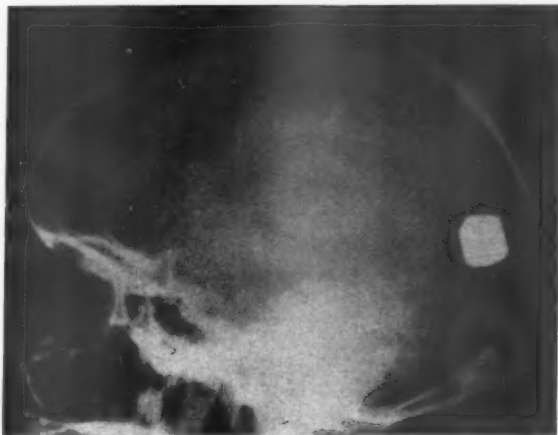


FIGURE IX.

Five days after his admission to hospital, pus discharged from the centre of the fungus, which rapidly receded to the level of the skull. A probe could be passed down along the track of the discharge for about five centimetres. His facial paresis now disappeared, some movement returned at the shoulder and elbow joints, and his leg movements became much stronger.

After one cubic centimetre of "Thoratrast" was allowed to trickle down the track, X-ray examination showed it leading to a well-defined cavity beneath the bone defect.

Case III. Spontaneous Discharge of Abscess Connected with Foreign Body.

A young British trooper was admitted to hospital twenty-four days after being wounded. He had been hit while in his tank and had slowly lost consciousness for a very short time. On recovery, he noticed that his right side was paralysed. The following day *débridement* was performed at a forward unit. He eventually arrived at the head centre, and on admission was in good condition and alert. He had an open wound in the left side of the head near the vertex,

from which a long narrow streak led back to the foreign body in the occipital lobe. (See Figure X.) This examination was followed by most severe reaction, with headache and vomiting and a temperature of 101° F. The patient's condition was alarming. The cerebro-spinal fluid pressure was 300 millimetres and the fluid contained 5,000 cells per cubic millimetre. The following day the cell count rose to 17,050. He was given

intravenous injections of "M & B 693", and after two days commenced a rapid recovery.

As this large foreign body appeared to be connected with the abscess cavity, it was decided to attempt its removal. A two-stage operation was done. At the first sitting a small osteoplastic flap was made over the occipital region where the foreign body appeared to be nearest to the surface. The dura was opened and the edges of the field were treated with endothermy. Three days later the wound was reopened. It was now discovered, to our surprise, by striking with a brain needle, that the body lay at a depth of five centimetres from the sur-

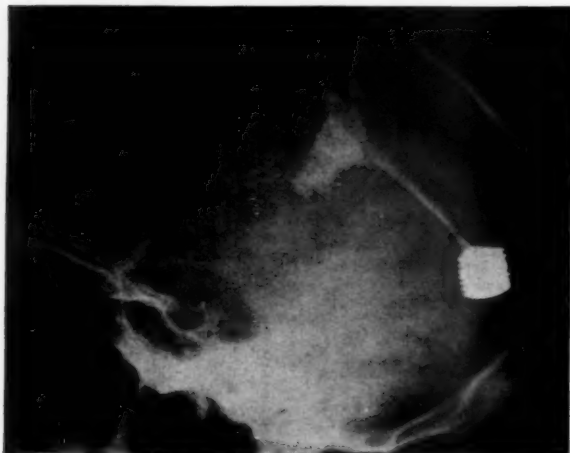


FIGURE X.

face. It was non-magnetic. It was thought that its removal through this depth of healthy brain would be a most damaging procedure, and no more was done. If at some future date an abscess should form, a safe way will already be in existence for its attack.

The patient proceeded to make good recovery, and when last seen his hemianopia had completely cleared, his leg movements were strong, and the power and sensation of his hand and arm were greatly improved. His original wound had ceased to discharge, and the operative wound had healed cleanly.

In this case, a difficult decision had to be made between doing a damaging operation in the presence of active infection and the alternative of leaving a large foreign body *in situ*. It is felt that a rational compromise was used by preparing a way in case of future trouble.

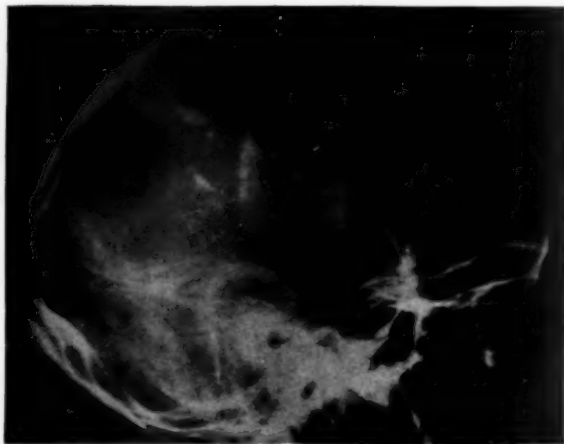


FIGURE XI.

Case IV. Cerebral Abscess Complicated by Fungus Cerebri and Meningitis: Recovery.

A private of the New Zealand Expeditionary Force was admitted to hospital eighteen days after injury. He had apparently been lost in the desert for five days after injury, and there was no history of any early treatment. He eventually reached the base and was transferred to the neurosurgical centre because of the gravity of his

condition. He was emaciated, drowsy and uncooperative, and lay curled up on his side, with marked head retraction. He was incontinent of urine and faeces. He had complete visual inattention in the right field and bilateral papilloedema. He had a complete right hemiplegia with increase in deep tendon reflexes and ankle clonus. His tongue was dry and dirty. There was an open wound in the left parietal area near the mid-line through which protruded a most offensive *fungus cerebri* measuring two by one inches. The cerebro-spinal fluid pressure was 300 millimetres. The fluid contained 1,200 cells per cubic millimetre and was sterile. His blood sulphonamide content was 6.25 milligrammes *per centum*. X-ray examination revealed deeply indriven fragments of bone in the left hemisphere. (See Figure XI.)

Management of this case was difficult owing to the patient's extremely feeble state. For six days sulphonamide was pushed until his sulphonamide serum concentration reached 11.7 milligrammes *per centum* and his leucocyte count was 10,000 per cubic millimetre. Lumbar puncture was performed every day, and the cerebro-spinal fluid pressure was reduced to 100 millimetres. The wound was very rapidly improved with iodoform dressings. He was then given one and a half pints of blood by the slow drip method, and on the sixth day after his admission to hospital his condition warranted operation.

Under "Pentothal Sodium" anaesthesia the wound was enlarged and bone was cut away at the side of the fungus. The dura was treated with the endotherm, and exploration through this area revealed an abscess at a depth of two centimetres. A considerable quantity of thick yellow pus poured out and a tube was inserted. Some bone fragments were removed. Drainage ceased at the end of six days. The patient's general condition rapidly improved, though he remained disorientated for several days. At the end of a fortnight his hemianopia had disappeared and he was using his right arm and leg. The fungus had subsided, but a small sinus led into the hemisphere and a probe could touch a remaining bone fragment. Before this could be removed the New Zealand authorities invalidated him home.

Case V. Small Abscess in Hemisphere with Widespread Signs; Rapid Recovery.

A young British trooper had been wounded in action about three weeks previously. A left-sided penetrating skull wound had been cleaned and sutured in a forward area. At first he had had some left-sided weakness and aphasia, which had improved; but some days prior to his admission to hospital he had got bad again and became drowsy. On admission he was drowsy but cooperative. His right hand and arm were paralysed and astereognostic, his right leg was weak, he had a right homonymous hemianopia and papilloedema. The cerebro-spinal fluid pressure was 350 millimetres.

At immediate operation the wound was reopened, and at a depth of two centimetres below the wound a small abscess cavity containing about half an ounce of pus was drained. Drainage ceased in two days, and the only organism grown was *Staphylococcus albus*. Within twenty-four hours of operation most of the patient's signs had disappeared. He continued to make rapid progress and was soon up and about.

This case is reported in detail because of the widespread nature of his signs, their association with such a small abscess, and the extraordinary rapidity of recovery.

SUMMARY.

Fifty cases of open head wounds sustained in a Western Desert battle are discussed. This is probably one of the largest series of such cases collected in this war. The peculiar conditions of the campaign resulted in a high incidence of infection.

The types of infected wounds are discussed: (1) Infection of scalp wounds and its consequences. (2) Infection of skull fractures. (3) Infections in the brain: (a) infected tracks, (b) abscesses.

Some individual cases of abscess are reported in detail.

ACKNOWLEDGEMENT.

I am indebted to Colonel MacAlpine, Consultant Neurologist, Middle East Forces, for his helpful interest in all these cases. Captain Savage, Royal Army Medical Corps, very kindly reproduced the X-ray plates.

EXCISION AND PRIMARY SUTURE OF WOUNDS IN WAR SURGERY.¹

By W. A. HAILES,

Colonel, Australian Army Medical Corps, Australian Imperial Force.

It is well recognized that we are prone to commence a war using those methods in vogue at the termination of the preceding one. This criticism is applicable to the medical service just as much as to the combatant.

The war of 1914-1918 commenced with the practice of surgical procedures carried out in the Boer War and ended with the treatment of some classes of wounds by excision and delayed primary suture; indeed, in some cases, excision and primary suture. This is a well recognized technique in certain ideal circumstances in the traumatic surgery of civil life. It was only to be expected that those senior surgeons who had to deal with the problems on the spot would and did recognize the conditions. As a consequence, surgical procedures of the last war and civil practice were reviewed and quickly seen in true perspective.

Articles dealing with the immediate treatment of battle casualties have appeared in number in medical and surgical journals. The writers of these articles have had, in some instances, no first-hand knowledge of conditions. Despite this shortcoming, some have not hesitated to advocate procedures which are thoroughly unsuited to the circumstances and are fraught with tragic results. The writers of some of these articles are so well known that it is occasionally necessary to refute their assertions. If this is not done, the consequences are apt to be serious indeed, because of the activities of the disciples of these contributors.

There have been many references in the literature to excision of wounds and primary suture. Volume xi, Number 4, of *THE AUSTRALIAN AND NEW ZEALAND JOURNAL OF SURGERY* contains an article by Hugh Poate advocating, in certain circumstances, this procedure in war surgery. This treatment has been so soundly criticized and condemned by those acquainted with the various types of war wounds and the difficulties of their treatment and evacuation that the position must be clearly stated.

It has been the experience of many of those in authority in surgical units working in areas in which the Australian Imperial Force has fought that this procedure, excision and primary suture, has been "the surgical fancy" that has caused most apprehension and needed most control.

Under conditions of mobile warfare which existed in Libya and Syria, and there is no reason to believe that the surgical problem will be any easier should this form of warfare come to Australia, the writer of this article wishes emphatically to contradict those authors who have sponsored excision and primary suture, and to affirm that in modern mechanized warfare the words excision and primary suture should find no place in any article on surgical treatment, except in those regions of the body referred to in the instructions of the Director of Medical Services, Australian Imperial Force, mentioned by Mr. Poate.

Excision and primary suture might possibly be carried out by a few surgeons if a soldier were wounded at the entrance to a base hospital. This might be the single exception to the previous paragraph.

¹ Accepted for publication on June 8, 1942.

The extent and nature of the wounds caused by land mines, anti-personnel bombs and mines and other modern high explosives are such that complete excision alone is difficult. He would indeed be a confident surgeon who could guarantee that the excision was complete. It is fortunate that it is usually evident to most surgeons that primary suture would be nothing more than "a criminal procedure" in these circumstances, as indeed it is so described in an article in Volume xi, Number 4, of *THE AUSTRALIAN AND NEW ZEALAND JOURNAL OF SURGERY* by a casualty clearing surgeon. There are, however, those who are always ready and willing "to chase the rainbow". Articles such as those referred to only encourage these surgeons and increase the responsibility of the senior surgeons on the spot.

The authors of some of these articles have deservedly a high place in surgery and as such have a considerable following; but I must warn all who may have been stimulated by these surgical messages and intend to put the principles enunciated into practice, that, while the surgical section of the Medical Directorate is as at present constituted, such action will assuredly cost them their surgical positions. They will be moved to positions in which the consequences of their actions will be less lamentable. In the campaign in Libya and Syria, it may be said, without fear of contradiction, that in major injuries of extremities with gross damage to soft tissues "the aseptic healing" referred to was unknown.

Writers have also led readers to believe that it is only a question of "pushing the operating and resuscitation teams far enough forward" and all the visions of the armchair critics will be fulfilled. I would remind those interested that little has been said about the trials of the journey down the long line of communication, of the impossibility of surgical supervision on this long line, and I ask whether anyone who had a surgical experience and a concern for his patient would subject a patient with a compound fracture of the femur (from a war wound) to excision and primary suture and almost immediate evacuation, knowing the very difficult and uncertain conditions that lay behind.

Primary suture following excision of any wound in traumatic surgery should imply undivided responsibility. The surgeon who sutures the wound must accept full and undivided responsibility to the end. Only then will he learn and be impressed by the results of his actions.

This war has taught a group of surgeons from all the States that the surgeon who performs the first operation in a case of gunshot wound of the femur truly carries that man's life in his hands. If he wishes to throw some of those lives away, he can practise excision and primary suture. This latter procedure is no concern of a casualty clearing station surgeon, who will probably be the first surgeon to see the wounded soldier. That surgeon should be unaware that such a procedure is possible.

Surgeons of the Australian Imperial Force know the opinion of their Royal Army Medical Corps colleagues in the Middle East on the subject of primary suture. It would be presumption on my part to speak for them. Suffice it to say we are not alone in our opinion. Those who refer easily to "pushing as far forward and dispersing as widely as possible" the operating units, just do not know and cannot visualize the conditions in the Western Desert. It may help them if they realize that in the space of ten weeks some surgical operating units were prisoners of war, captured and released, and only by the resource of a good leader saved from being captured again. That at least should show that the medical service is attempting to supply an operating service in the forward area.

The medical service has no intention of trying excision and primary suture. It has, in fact, forbidden it. It has tried and tried hard to solve the

problem of the early and efficient surgical treatment of the soldier wounded in the forward areas in mechanized warfare and of the subsequent difficult evacuation. Though progress has been made, much yet remains to be accomplished.

I have no wish to enter any discussion now on the relative merits of Thomas splints and spica plasters for immobilization of the fractured femur either before or after surgical treatment, and do so only because reference is again made to an instruction of the Director of Medical Services, Australian Imperial Force.

It is, however, necessary to state that with the literature on surgical work in the Spanish War, so freely quoted by writers, at our disposal, it would have been unwise not to try the plaster method for fractures of the femur. The hospital at Tobruk had the orthopaedic apparatus necessary for this treatment and used it. It would indeed have been difficult to evacuate these patients using any other method. The surgeon in Syria referred to could not have used the method because no Australian Imperial Force surgeon in Syria had the orthopaedic apparatus necessary. Without such apparatus, that treatment not only increases shock but is inefficient.

I am convinced that both methods have their uses, but personally believe that the Thomas splint method of evacuation is both preferable and capable of more general application, but certainly not with a clove hitch. In the Middle East the clove hitch was considered inferior to a pin through, or a clip on, the boot. All three methods can and do cause injury to the foot, and the clove hitch was the most frequent cause of trouble.

In the Australian Imperial Force extension by means of a clove hitch was permitted only as far back as the main dressing station. The same restriction applied to the pin and clip. It is immaterial whether the clove hitch is applied over the laced or the unlaced boot. If it is applied and maintained over the long line of evacuation, the pressure sores referred to are only one of the resulting disabilities. There were several cases of ischaemia of the feet following evacuation with a clove hitch extension. This condition shows little tendency to improve. The result appears to be a painful, wasted and useless foot.

In the plethora of advice offered in surgical literature on the problem of excision and primary suture and extension during transportation for the fractured femur, it may be difficult for surgeons to assess the relative values. It may help critical readers to know first of all that it is well known what surgeons had extensive experiences in these problems and the opinions they held; secondly, that I was responsible for the advice given to the Director of Medical Services, Australian Imperial Force, on surgical problems. Though that advice might vary for geographical or other reasons, had I to draft paragraphs 1, 3, 7 and 10 referred to again, the only paragraph that I would alter at all in any circumstances is paragraph 3, and that only to permit of a few approximation sutures in the amputation flaps of recently injured extremities in contrast with amputations for old or already infected wounds. If the writer who quoted the paragraphs referred to had included the date of that Director of Medical Services instruction, it would have been obvious to all that paragraph 10 referred to some medical officers who were contemplating primary suture and were about to embark for Greece! Evacuation from Libya was bad enough. We foresaw that. That from Greece was likely to be beset with as great or greater difficulties. Had those instructions to be rewritten in similar circumstances, not one word would be altered. In the third place I should like critical readers to know that the Medical Directorate of General Headquarters, Middle East, conducted a surgical conference in

February, 1942, at which these problems, amongst others, were discussed. The writer was present at those meetings.

THE USE OF POWDERED SULPHONAMIDE.

Powdered sulphonamide is of undoubted value in freeing granulating wounds of streptococci. That alone would seem to assure its value locally after excision.

Readers are warned that there is a difference between the action of sulphonamide powder and crushed tablets. Sulphonamide powder in the Middle East in the early and middle periods of 1941 was scarce indeed, and I regret that our casualty clearing stations never had anything but very limited supplies. There was considerable doubt whether the crushed tablets which contained an excipient were anything like as efficient as the powder. It is true that some of the sulphonamide was absorbed and could be measured in the blood stream, but concentration of two milligrammes *per centum* is not the optimum to be aimed at. A much higher concentration can be obtained by the oral method if much larger doses than one tablet every four hours are given. This subject was discussed by Captain R. Andrew in a paper in *The Medical Journal of Australia*, November 29, 1941, page 612. Some surgeons considered the powdered tablets undesirable and preferred to rely on sulphonamide given by mouth if sulphonamide powder was not available. Few, if any, army surgeons would sponsor the introduction of tablets into deep tracks. For those who wish details of the further treatment of these wounds by baths, sulphonamide powder and skin grafting, I would refer them to the article in *THE AUSTRALIAN AND NEW ZEALAND JOURNAL OF SURGERY*, Volume xi, Number 3, by Major B. K. Rank. There will be found all the technical details that were practised by him in Egypt.

Closed plasters have done little, if anything, to protect many wounds from cross-infection. It is possible to grow from the very copious discharge that collects inside the plaster and from the stain on the outside of the plaster the same organism as from the wounds treated by open methods. Plaster is very often the perfect splint. Those who have seen pus escaping from the top of or soaking through the splint, and this will assuredly happen in two to three weeks, will question its value in the localization of infection in a ward.

The whole tenor of some of the recent articles in surgical journals shows that the contributors cannot forget the types of wound that were experienced in the last war, so often one or two foreign bodies in an extremity. Let the reader imagine the different problem involved in the excision of those wounds and in the treatment of those injured from explosion of land mines *et cetera*. The picture has altered and must be seen to be appreciated. Nor can those writers forget the easy line of evacuation with ambulance trains at the casualty clearing station's back door. Australian Imperial Force surgeons who have personal experience are contributing to the College journal their impressions and results.

Surgical Technique.

OPERATION FOR HÆMORRHOIDS.¹

By DOUGLAS ROBB,
Auckland.

THE patient is admitted to hospital the afternoon before operation, and is given a simple enema in the evening. The skin around the anus and perineum is shaved, and a sedative is given for the night.

In the morning one-sixth of a grain of morphine and one one-hundred-and-fiftieth of a grain of hyoscine are injected subcutaneously forty-five minutes before operation. In the case of those patients who wish or require complete amnesia the same combination is given one hundred and twenty minutes and again sixty minutes before operation. Rarely a very robust and apprehensive patient requires a third injection as well ten minutes before.

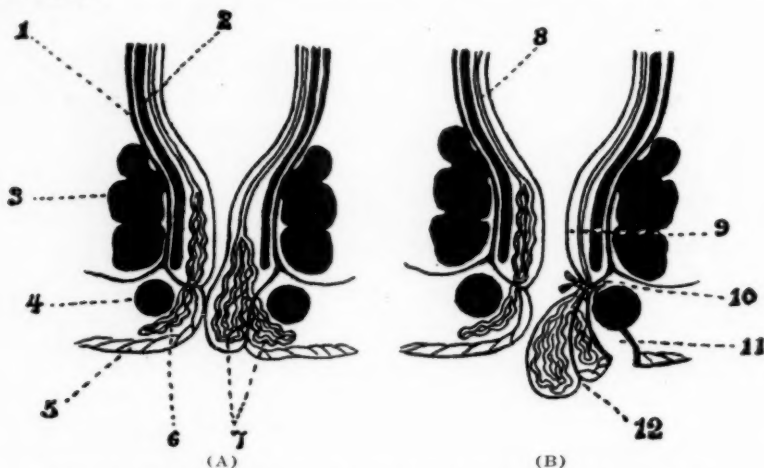


FIGURE 1. Diagrammatic coronal section of anal canal. (A): normal (on the left) and prolapsed hæmorrhoids; (B): skin cut and ligation of pile pedicle. 1: longitudinal muscle; 2: circular muscle; 3: internal sphincter; 4: external subcutaneous sphincter; 5: corrugator cutis ani; 6: normal hæmorrhoid; 7: prolapsed hæmorrhoid; 8: hæmorrhoidal vein; 9: dragged down rectal mucosa; 10: ligated pedicle; 11: skin cut; 12: attachment of longitudinal muscle to muco-cutaneous junction. (Reproduced from *The Lancet*, November 13, 1937.)

The patient is placed in the lithotomy position, with buttocks well over the end of the table and the head end of the table slightly lowered. The scrotum is held out of the way with a towel, and the skin is painted with tincture merthiolate or Harrington's solution. A swab of antiseptic solution is kept at hand to repaint the skin before fresh punctures are made.

Anæsthesia by local infiltration is the method of choice; 1% "Novocain", with or without adrenaline, or one in 2,000 "Pericaine", with or without adrenaline, is used. Ten to twenty cubic centimetres are injected with a fine needle under the skin around the anus and into the subcutaneous sphincter, through two wheals about two centimetres on each side of the orifice. The upper part of the anal canal and the internal sphincter muscle mass are anæsthetized from the same two lateral wheals with a fine needle seven to eight centimetres long. The left forefinger is lubricated and passed into the anal canal and acts as a guide, so that the solution may be deposited all round in a

¹ Accepted for publication on October 30, 1941.



FIGURE II. A ten cubic centimetre syringe containing "Proctocaine" infiltrating the subcutaneous tissues of the anal canal and the subcutaneous portion of the external sphincter. Left index finger in rectum as a guide.

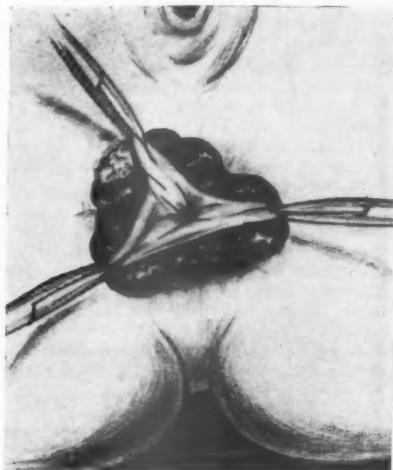


FIGURE IV. The Saint Mark's triangle after traction on the pedicles of the three primary masses. Secondary internal piles are seen below and outside the sides of the triangle.



FIGURE III. The left lateral primary mass displayed by traction with one forceps on skin-covered region and a second on the purple-coloured mucosal region. Between the forceps is seen the groove caused by insertion of longitudinal muscle. The paler normal rectal mucosa above the internal pile cannot be seen. The two other primary masses on the right side have not yet been pulled down.



FIGURE V. The left primary mass being removed. The first two skin cuts have been made, meeting at a point lateral to the outer edge of the subcutaneous band of external sphincter. Each cut will be carried up a little further than shown (see dotted lines). The inner edge of sphincter band is shown and above this the lower extremity of the longitudinal band coming down to meet the skin. This band is not divided. X indicates the spot where the transfixing needle enters. A: pedicle forceps; B: skin forceps.

submucous situation without the needle point being allowed to penetrate into the bowel lumen. Each segment of the internal muscle mass in turn is then hooked down with the tip of the left index finger, and two to three cubic centimetres of the solution are injected into it. Its tone melts away, and when the circuit is complete the ring is impalpable. The whole anal canal is now relaxed and pouting, and the hæmorrhoid masses may be gently pulled down and inspected.

Before the operation is begun five to ten cubic centimetres of "Proctocaine", or other oily solution of local anæsthetic, are distributed in the subcutaneous sphincter and under the skin of the lower part of the anal canal. The lower part of the rectum and the anal canal are now washed out with swabs soaked in 50% ethereal soap and water and dried, and a final painting with antiseptic is given to the perianal skin.

An alternative form of anæsthesia is that produced by the "low spinal" method. In this method 0.4 cubic centimetre of 10% "Stovaine" or heavy "Percaïne" is injected into the subarachnoid space between the fourth and fifth lumbar vertebral spines. The patient remains in the sitting position for two minutes and is then placed in the lithotomy position for operation. "Proctocaine" is used as above. Anæsthesia is prompt and perfect, the only disadvantages being that the sitting position for the lumbar puncture precludes the heavier premedication, and the slight but definite dangers



FIGURE VI. The left pile mass has been transfixed and ligated. It may be cut off distal to the ligature now or after ligation of the other two primary masses.



FIGURE VII. Tube and pin in position, showing how wounds in skin tend to close when the tube is inserted. The dressing between tube and anal canal has not yet been applied.

attending spinal puncture are present. There are no immediate general effects, such as fall in blood pressure, but headache occurs in a proportion of cases and mars an otherwise good performance.

Tissue forceps or small artery forceps grasp the skin just below the white line of the muco-cutaneous junction at the three points—the 4 o'clock, 7 o'clock and 11 o'clock positions—above which lie the three main pile masses. Gentle traction displays both the degree of skin redundancy and the size of the red mucosa-covered internal portion of the pile to be dealt with. At the point where the red-purple colour gives way to the browner normal rectal mucosa above, a second clip is placed to mark the upper limit of the pile tissue to be removed on each of the three main pile masses in turn. When the three upper clips are pulled down, their points are joined by ridges or bars of brownish mucosa to form a triangle. Any secondary piles, between the three main ones, are seen to lie entirely below or outside these bars, and are ligated separately after the three main ones have been dealt with.

The dissection and ligation of the piles are done in turn clockwise from the pile in the 4 o'clock position. Two scissor cuts, meeting peripherally to make a V, mark out the extent of skin to be taken. Light snips in the areolar tissue under the distended or thrombosed perianal veins soon display the subcutaneous band of external sphincter.

At the medial border of this the strong intermuscular septum passing down to be inserted into the skin near the white line, is seen and defined. The edges of the pile are freed a little more, and its pedicle is transfixed with stout (number 8 or 10) plaited silk, the needle piercing the septum and emerging in the rectum just above the point of the upper clip. The pedicle is wholly encircled, and the silk is tied with the knot to the lumen and the pile is cut off. Any bleeding vessels are clipped and ligated with fine silk. The three main masses are dealt with in turn, and then one, two or three secondary piles if present. In all cases vertical columns of skin and mucosa are left between the tissue stripped up and removed. A finger now passed into the rectum feels the ring of knots, but no stricture. The V-shaped areas of skin denudation are also seen to have contracted into radially disposed slits. Any remaining skin tags are now snipped off.

The operation is completed by placing in the canal a rubber tube one centimetre in diameter and wrapped in two layers of gauze impregnated with cod liver oil and "Vaseline", and perhaps lightly packing around it with more gauze of the same kind. A safety pin through the tube and a perineal T bandage hold the dressing in place.

Almost no pain is experienced during the convalescence. The "Proctocaine" keeps the exposed portions of the sphincter numb and relaxed for about fourteen days, by which time healing is well nigh complete. The tube is taken out after twelve to twenty-four hours, and difficulty with the bladder is relieved by "Doryl" or "Esmodil". The bowels are opened with a gruel and olive oil enema on the third morning. The daily routine from the fourth morning onwards is breakfast, bowel action, bath and dressing. The dressing consists in everting the anus, lightly dabbing and cleansing the unhealed areas with a solution of "Dettol" and tucking a little gauze, impregnated with cod liver oil and "Vaseline", into the canal opposite the sites of the former hæmorrhoids. The gloved finger is passed about the seventh, fourteenth and twenty-first days to confirm progress in healing and absence of narrowing. Rarely is it necessary to pass a dilator.

Acknowledgements.

It is impossible to conceal the influence of the Saint Mark's Hospital practice in this account. Acknowledgement is gladly given to Mr. Milligan, Mr. Gabriel, and Mr. Naunton Morgan for guidance in the past. The illustrations were made by Miss E. B. Sellenger at operations, and the explanatory anatomical diagrams are taken as they stood from the article of Milligan, Morgan, Jones and Officer in *The Lancet*, Volume ii, 1937, page 119, entitled "Surgical Anatomy of the Anal Canal and the Operative Treatment of Hæmorrhoids".

Case Reports.

CASES OF LUNG INJURY FOLLOWING EXPOSURE TO BLAST AND NITROUS FUMES.¹

By F. J. BOOTH,

Captain, Australian Army Medical Corps.

THE study of the cases here reported has been by no means complete owing to the pressure of work in handling a large convoy of seriously ill patients at one time. An attempt has been made, however, to investigate those features of the living pathology which may serve as a guide to the scientific treatment and a check on the progress of the patients.

These soldiers were being evacuated from Crete on May 29, 1941, and about 15.00 hours on this date the cruiser was hit by bombs of large calibre. As a result of this the patients were exposed to severe blast and the nitrous fumes of burning cordite. Unfortunately, it has not been possible to obtain a clear account of their state between the time of the above incident and their admission to hospital on May 30 about 02.30 hours.

Case I.

Sapper, aged twenty-one years, was admitted to hospital dangerously ill. There were some degree of mental confusion and marked cyanosis, with a temperature of 98° F., a pulse rate of 130 and a respiratory rate of 30 per minute. He was coughing up frothy bloodstained sputum, and there were moist sounds throughout both lungs, with an impaired percussion note over both bases. He was given continuous oxygen, with disappearance of the cyanosis, a fall in the pulse rate to 110 and a marked clearing of the mentality. Towards evening the temperature had risen to 100° F., the pulse rate to 120 and the respiratory rate to 55 per minute, although he was still having continuous oxygen. The following day he was given eight grammes of sulphapyridine and intermittent oxygen therapy. Thereafter he was given one gramme of sulphapyridine every four hours until the clinical condition was silent for forty-eight hours. Recovery was uneventful, with the exception of an attack of right-sided pleural pain and intermittent rises in the pulse rate, respiratory rate and temperature. An X-ray picture taken on June 9 revealed a slight, diffuse, mottled, woolly shadow throughout both lungs and a moderate increase in the transverse diameter of the heart. On June 12 the lungs and heart appeared clear, and he was fit to be transferred to a British hospital for further rest.

Case II.

Lance-corporal, aged twenty years, was admitted to hospital dangerously ill. There were a marked degree of cyanosis, a temperature of 100° F., a pulse rate of 120 and a respiratory rate of 30 per minute. There were numerous moist sounds throughout the lungs and an impaired percussion note, especially over the right base. He was given adequate amounts of continuous oxygen, with disappearance of the anoxic features; but the temperature and respiratory rate showed a steady rise, and the respirations were very deep in character. The following day the temperature had risen to 105.5° F., and the respirations were 70 per minute. The patient was very restless, and the intermittent administration of oxygen was possible only after injections of one-sixth of a grain of morphine. Eight grammes of sulphapyridine were given with marked improvement. Thereafter recovery was uninterrupted, one gramme of sulphapyridine being given every four hours. On June 12 he was transferred to a British hospital.

Case III.

Private, aged twenty-two years, was admitted to hospital dangerously ill. He was semi-delirious, with marked cyanosis, a temperature of 98° F., a pulse rate of 145 and a respiratory rate of 40 per minute. He was vomiting and coughing up yellow sputum. There were moist signs throughout the lungs and impairment of the percussion note, particularly over the left base. Oxygen was administered continuously, with disappearance of cyanosis and a drop in the pulse rate to 120. On the following day adequate amounts of oxygen were given intermittently, along with eight grammes of sulpha-

¹ Accepted for publication on April 14, 1942.

pyridine in divided doses. Later this therapy had to be stopped temporarily on account of hæmaturia. An X-ray picture taken on June 9 revealed a marked generalized fluffy appearance of both lung fields with a small effusion in the left costo-phrenic angle. The effusion on aspiration was found to be bloodstained and sterile. These examinations were followed two days later by a flare up in the patient's condition, the temperature rising to 103° F. and the pulse to 140, with marked exacerbation of the signs in the lungs. On the whole, the progress of this patient has been rather unsatisfactory on account of a low-grade pulmonary infection. The patient is still in hospital confined to bed with slight pyrexia, tachycardia and marked general weakness.

Case IV.

A.C.2, aged nineteen years, was admitted to hospital dangerously ill. He was unconscious, deeply cyanosed and very restless. The temperature was 104° F., the pulse rate 140, and the respiration stertorous, with a rate of 70. There was a hæmatoma of the scalp over the right frontal bone near the middle line and just in front of the fronto-parietal suture. Examination of the lungs revealed numerous moist sounds and impairment of the percussion note over both bases. Continuous administration of oxygen was made possible by injections of morphine. On the following day adequate amounts of oxygen were given along with eight grammes of sulphapyridine. His condition showed marked improvement on this therapy. On June 2 he regained consciousness, but there was a retrograde amnesia of over sixteen hours. There were hæmorrhages into the left ocular fundus, and also a marked increase in the deep reflexes of the left side, with ankle clonus, paralysis of the physiological flexors of the left ankle joint and anaesthesia of peroneal distribution. X-ray pictures taken on June 9 revealed no fracture of the skull, but a fluffy appearance in the lung fields, with a moderate increase in the transverse diameter of the heart. Two days following this examination the patient developed a right basal pneumonia, which responded well to sulphapyridine. He is still in hospital confined to bed with a resolving pneumonia, a partial pyramidal lesion and peroneal nerve paralysis.

General Considerations.

1. Attention is drawn to the difficulty in differentiating between pulmonary concussion or blast lung and poisoning from nitrous fumes in the absence of a clear history. Fortunately this is of no great significance since indications for treatment in both conditions are practically identical.

2. The importance of bearing in mind the possibility of multiple lesions in conditions resulting from high explosives is illustrated in Case IV.

3. In the initial stages of injuries of this nature anoxia dominates the clinical picture, and the only way of combating this is by the adequate administration of oxygen, controlled by accurate observations of the mental state, the pulse rate and the presence or absence of cyanosis.

The above patients required an average oxygen flow of seven to eight litres per minute, using the Haldane mask, continuously on the first day and during interrupted periods dictated by the clinical state on the second day. The restless, irritable condition of the patients in Cases II and IV made necessary the use of morphine before oxygen could be effectively administered. An interesting point was the slight effect of oxygen in diminishing the ventilation rate of the lungs. As in the case of left heart failure, this is probably due to the fact that the dyspnoea is mainly reflex in origin from the congestion of the pulmonary bed and not due to changes in the carbon dioxide or oxygen tensions of the blood.

It is to be regretted that the content of the oxygen cylinders on issue in the Army is marked in gallons and the flow meters register litres per minute; but, since one gallon equals approximately 4.732 litres, it is easy to calculate the amount of oxygen required in any given case. Roughly speaking, with the usual oxygen flow of seven to eight litres per minute with the Haldane mask, eight large cylinders with the capacity of 250 gallons each are required during a period of twenty-four hours.

4. Further, the very real risk of a superimposed bacterial infection must be constantly borne in mind in the treatment of these injuries. The physical exhaustion and undernutrition of soldiers on active service, in conjunction with the above lesions, would lower the resistance and favour the spread of latent or mild infections of the upper respiratory tract into the depths of the lungs. This reasoning was borne out by the experience of the above casualties: on the third day following the original injury there was clinical evidence of a pulmonary infection which responded to sulphapyridine therapy.

5. The importance of enjoining prolonged rest in bed in the more severe cases of this type cannot be over-emphasized. Even the mild physical exertion of being subjected to an X-ray examination, as shown in Cases III and IV, may be enough to precipitate an exacerbation or relapse of the lung condition.

NOTES ON SOME CASES OF MULTIPLE INJURIES RESULTING FROM BOMB EXPLOSION.¹

By L. G. TRAVERS,
Captain, Australian Army Medical Corps.

OWING to the fact that 80 odd patients were admitted to a small hospital, which had a correspondingly small staff, in the space of an hour or two, these notes are by no means complete.

The interest lies in the unusual combination of injuries, the causal agent being a bomb which exploded between decks in a cruiser laden with troops during evacuation from Greece. The injuries sustained were: (a) pulmonary concussion, (b) nitrous fumes poisoning, (c) burns, (d) fractures in various combinations.

Captain Booth has given a full account of the cases of purely medical interest—that is, those in which the patients suffered from blast and nitrous fumes poisoning. The patients mentioned below were admitted to the surgical side as the burns and fractures appeared to be the predominant injury, though the chest conditions presented serious difficulties.

The bomb explosion caused quite definite signs and symptoms of blast injury and even produced surgical emphysema in the neck and thorax in the absence of fracture anywhere in the thoracic cage. The same agent caused fractures of *os calcis* and spine by the sudden lift of the deck on which the men were standing. The bomb exploded the cordite and the burns were produced by cordite flash coming up the ammunition hoist. The fumes produced were responsible for some pulmonary irritation, alone or in combination with blast injury.

The burns, though extensive, were in no case more than severe second-degree burns. They were confined to those areas which were completely unprotected, and even the lightest clothing gave protection. Unfortunately, owing to the hurried evacuation, some troops were wearing neither stockings nor shirts.

With one exception the general condition of the patients permitted a start to be made straight away in the treatment of those with burns and fractures; even if the pressure of work had permitted, the state of shock was not sufficient to warrant extensive resuscitation, apart from elementary procedures to limit shock: injection of morphine, application of warmth *et cetera*. No intravenous therapy was considered really necessary.

"Pentothal Sodium" was the anæsthetic used. The clothing was removed, and the burns were treated with 20% tannic acid on arms, legs and trunk. *Tulle gras*, over which wool soaked in saline solution was placed, was used on face and hands. Fractures were immobilized in plaster. Two to three hours later, however, there was a serious change in the condition of the patients in that pulmonary signs and symptoms suddenly supervened. Respiratory distress was predominant: dyspnoea and cyanosis were very pronounced, with generalized moist sounds and the pulse rapid and weak. Combined with this was post-operative shock from the handling of the burns and fractures, and this presented a problem in treatment. It was felt that intravenous therapy was inadvisable and would overburden an already acutely embarrassed pulmonary circulation. It is possible that the diminished blood volume, by fluid loss from the burnt areas, may have relieved the pulmonary condition.

Oxygen was administered intermittently through nasal catheter because the equipment was inadequate for the treatment of so many patients at the one time continuously. The "B.L.B." masks were taken up by the purely medical patients, and the difficulty of applying a mask to burnt faces precluded their use even if they had been available.

The surgical emphysema may have been present on admission and undetected, but was obvious a few hours later. It is unfortunate that it was not possible to have all the patients submitted to X-ray examination; but the one patient (E.K.) whose thorax was examined by X rays showed no evidence of fracture of the thoracic cage, though surgical emphysema was pronounced in the neck and upper part of the thorax. It is interesting to note that the emphysema was always first noted at the root of the neck, coming to the surface through the mediastinum.

¹ Accepted for publication on April 14, 1942.

CASE I.—Private, aged twenty years, was admitted to hospital at 12 o'clock midnight acutely distressed and desperately ill, with the diagnosis of multiple fractured ribs. There was a small amount of blood-stained sputum which did not last long. There was gross surgical emphysema extending from the chin to the costal margins. The patient was too ill to be examined thoroughly for fractures and the emphysema made lung examination difficult; but it was possible to determine displacement of the heart to the right side with valvular pneumothorax to the left.

A needle was introduced and air was withdrawn with considerable relief, but his condition deteriorated and death occurred twelve hours later, without increase in pneumothorax, in spite of oxygen and "Coramine" administration. After death thorough examination failed to reveal any thoracic fracture, and unfortunately it was not possible to perform an autopsy.

CASE II.—E.K., private, aged twenty-eight years, was admitted to hospital at 12 o'clock midnight on May 30, 1941. This man had extensive first- and second-degree burns of face, arms, hands and legs from the mid-thigh to the ankles. Small petechial hæmorrhages were noted over the front of thorax.

"Pentothal Sodium" was administered, and the burns were cleaned up and tannic acid 20% was applied, except to the face and hands, for which *tulle gras* and saline solution were used. Two hours later dyspnoea and cyanosis were pronounced, moist sounds were audible in both lungs, and the patient was considerably shocked. Emphysema was noted at the root of the neck and the upper part of the thorax. Oxygen was administered by nasal catheter, and "Coramine", one cubic centimetre, was given every two hours.

On the evening of May 31, 1941, the temperature rose to 102° F. with definite pneumonic signs at the bases of both lungs. Respirations numbered 40 a minute and the pulse rate was 130. Emphysema had extended to below the nipple line on both sides, at which level it remained. The petechial spots were well marked and did not fade for some days. It is presumed that they were produced by the blast and they resembled in no way the toxic rash exhibited by some of the other patients with burns (see Figure I).

Sulphapyridine eight grains daily was given. By June 6, 1941, the patient's condition started to improve and recovery from then on was uneventful. The burns were healed by June 11, 1941. X-ray examination of the chest on this date failed to reveal any fracture.

CASE III.—J.R., gunner, aged twenty-three years, was admitted to hospital on May 30, 1941, with second-degree burns of face, hands, arms, thighs and legs. He also had bilateral fracture of the *os calcis*. Some emphysema was present at the root of the neck, but was not gross.

"Pentothal Sodium" was administered, the burns treated as in the previous case, and both feet were put in plaster. Four hours later the patient's temperature rose to 103° F. Respirations numbered 38 per minute and the pulse rate was 132. The patient was delirious and distressed with dyspnoea and cyanosis. Moist sounds were numerous in both lungs. There was a small amount of sputum, which was not blood-stained.

On May 31, 1941, the patient had frank pneumonic signs, and sulphapyridine, eight grammes daily, was given. He remained irrational for the next eight days, and considerable difficulty was experienced in keeping him in bed. His condition precluded adequate treatment for the *os calcis* fractures. He developed a toxic rash on the trunk. The burns became infected, tan had to be removed from hands and arms, and saline baths with *tulle gras* and saline solution dressings were substituted. He developed corneal ulceration in the right eye.

By June 12, 1941, the burns were healed except for small areas of almost third-degree burns on the fingers. The patient's mental condition was normal, his chest cleared and the corneal ulceration healed. Recovery from then onward was uneventful.

CASE IV.—Private, aged twenty-five years, was admitted to hospital on May 30, 1941, with bilateral fracture of the *os calcis* and complaining of pain in the back. X-ray examination revealed a fracture of the body of the first lumbar vertebra without much compression. Plaster was applied to the feet and a plaster bed was made for the spine.

Four hours after his admission to hospital the patient developed mild respiratory difficulties, and examination revealed signs of bronchiolar spasm with both inspiratory



FIGURE I.


and expiratory rhonchi, indistinguishable from a fairly acute asthmatic attack. His chest condition was probably due entirely to nitrous fumes irritation with no real blast element. This persisted for three days and recovery was uneventful.

CASE V.—B.W., private, aged twenty-three years, was admitted to hospital with second-degree burns on face, hands, arms and knees. "Pentothal Sodium" was administered and the burns were treated as before. The patient developed some emphysema at the root of the neck, and four hours after the anæsthetic was given was acutely distressed. Sputum was not profuse and was not at any stage blood-stained.

On the evening of May 31, 1941, the patient's temperature rose to 101° F. Sulphapyridine as before was given, and in two days the chest condition had settled well. On June 6, 1941, he developed frank pneumonia at the bases of both lungs; a toxic rash was well marked and developed into a troublesome furunculosis. The pneumonia was treated by the usual methods and recovery was uneventful.

The patients were all transferred to British hospitals when well enough, and it is not possible to give the end-results of the fractures.

It is regretted that the clinical notes and investigation of these cases were not more complete, but the task of dealing adequately with 80 seriously injured soldiers admitted at the one time by a small staff precluded this.



Surgery in Other Countries.

[In this column will be published short résumés of articles likely to be of practical value from Journals published in other countries and not readily accessible to surgeons in Australia and New Zealand.]

INTRACRANIAL VASCULAR TUMOURS, WITH REFERENCE TO A DIAGNOSTIC PROCEDURE.

Ragnar Bringel: "Tumor angiosus intracranialis (Diagnostischer Beitrag)", *Acta Chirurgica Scandinavica*, Volume lxxxii, 1939, page 190.

In his monograph on "Tumours Arising from the Blood Vessels of the Brain" Harvey Cushing advised a careful examination, including auscultation of the head, of patients who suffered from epileptic attacks or who complained of rushing noises in the head. The usual clinical signs given by such patients are: asymmetrical carotid pulsation (the stronger pulse being on the side of the tumour); unusually numerous and abnormally situated vessels outside the cranium; pulsating exophthalmos or occasionally ptosis and myosis; and all the general and local signs of cerebral tumour. The history is often characteristic. Epileptic symptoms predominate, appearing in the early years, then vanishing for one or more decades. They may reappear in middle age, as an effect of regressive changes in the tumour, such as thrombosis or calcification, or they may be produced in an acute form by such conditions as pregnancy, hyperplasia, alcoholism and so forth.

Bringel reports two cases to illustrate the value of this simple procedure when it is applied in a routine way in diagnosis.

The first case was that of a single woman, fifty years of age, who had suffered for some years from hyperpiesis, headache and anginal symptoms after effort or worry. After her bath one morning she became suddenly ill. She felt sick, suffered double vision, and complained of severe headache and giddiness. During the following week she developed a mild degree of right-sided hemiparesis, but was able to feed and care for herself. She was examined a week after the onset, when her diplopia was seen to be due to a bilateral weakness of the sixth nerve. There was mild right-sided facial paresis, but her right arm and leg, though slight convulsive movements were noticeable in them, were very little affected. Her neck was very stiff; Kernig's sign was not present, the plantar response was extensor on the right side. The left pupil was smaller than the right. There was no exophthalmus, and no pulsation was detectable in the eyeball. A mild degree of nystagmus, quick and irregular in type, was elicited on her looking to the right. The upper nasal border of both papillæ was effaced, and on the left there was some definite protrusion of the disk. On auscultation of the head, when the stethoscope was pressed hard against the cheek just below the zygoma at the level of the upper premolars, there was audible a short whistling, blowing murmur, "resembling the noise made by a cricket". This murmur was not heard over the vault, in the parietal or occipital regions. It was intended that when the acute symptoms subsided an arteriogram would be prepared to establish the presence of the suspected aneurysm; but the patient's condition became worse, and she died four days later. At the autopsy a ruptured aneurysm of about the size of a pea was found in the course of the left middle cerebral artery in the Sylvian fissure. The murmur in this case was heard on both sides of the head, but more loudly on the left than on the right. In the days preceding her death it was no longer audible, the suggestion being that its disappearance was due to progressive thrombosis in the vessels concerned.

The second case was that of a man, aged thirty years, who was admitted to hospital on account of repeated epileptic attacks. Examinations which included encephalograms and arteriograms, demonstrated the presence of an aneurysm on the left middle cerebral artery, but operation was deferred. Auscultation in this case revealed a faint but definite blowing murmur above the tip of the left ear. It was evident that this murmur was also audible to the patient himself.

The stethoscope used is the ordinary binaural one. Its chest piece must be of small diameter and faced with soft rubber to ensure close contact over the hairy parts of the scalp and to obviate hair noises. To increase the intensity of the murmur the patient is put through exercises aimed at increasing the amplitude of the pulse. If a deep inspiration is taken and held and is followed by a forced expiration, this also being held, the murmur will be found to be amplified to its maximum intensity. It can be registered if desired on that type of electrocardiograph designed for recording the heart sounds. In a search for the point of maximum intensity the stethoscope is placed over

the maxillary sinus on the cheek, directly below the zygoma. The murmur is well heard here on both sides, but better on the side corresponding with the tumour. This is probably due to the increased resonance imparted to it by the underlying air space.

Although modern methods involving radiology have largely diverted the attention and interest of physicians away from the more purely clinical investigation, this paper is intended to draw attention anew to Harvey Cushing's advice that careful auscultation of the head should be developed as a routine part of the examination of cerebral conditions.

ARTHUR E. BROWN.

THE UTERUS AS A CONTENT OF INGUINAL HERNIÆ IN MEN.

Olof Nilson (Piteå): "*Hernia Uteri Inguinalis Beim Manne*", *Acta Chirurgica Scandinavica*, Volume lxxxiii, 1939-1940, page 231.

The title of this article is arresting, but the most striking fact revealed is that out of 99 published cases in which the uterus was found to lie in an inguinal hernial sac, no less than 33, or one in three, occurred in males and only 66, the remaining two-thirds, in women to whom the uterus is generally supposed more properly to belong. These figures are from the material published by Motiloff in 1931, in which it is also stated that 21 of these 33 subjects were men with normal male sex glands and entirely normal male external genitals. Motiloff's material forms the main source of Nilson's article, along with a further case under his own personal care.

Nilson's patient was a twenty-three-year-old man who had been known to have a right-sided inguinal hernia at birth and had worn some sort of truss for the first eighteen months of his life. There was no testis in the right half of the scrotum, and this fact was known to the patient, who ascribed its absence to the gland having been pushed back by the truss. Since the age of fifteen he had had a left-sided inguinal hernia which filled the scrotum and which had latterly enlarged considerably. That part of the contents which reached the scrotum was easily reducible, but in the upper part of the canal there could be felt some abnormal contents after reduction of all the rest. There had never been any sign of strangulation. The patient was a sexually normal man who had enjoyed normal sexual intercourse, but who was not married and had fathered no children. Objectively the man was a strong young adult, with entirely normal masculine characteristics. The right testis was not palpable anywhere. On the left side there could be felt an apparently normal testis and in addition a hernia the size of a goose egg. The penis was normal and the prostate also appeared quite normal to palpation. At operation, after a large piece of omentum had been replaced, a uterus about half the normal size was found fixed at the level of the external ring. Traced deeper it was felt as a band about the size of the little finger going down into the pelvis, and from it there sprang from each cornu a structure which gave the exact appearance of a broad ligament, tube and ovary. On the left side these adnexa lay in the scrotum, but on the right they were intraabdominal, though they could be brought up out of the wound. Section of both of the glands concerned showed them to be testicular in structure. The uterus was amputated "supravaginally" and was removed with the left tube and sex gland. The right sex gland was laid back in the abdomen and left in place.

The specimen removed consisted of a supravaginally amputated uterus whose adnexa were, though small, entirely similar to those of normal women, with the exception that an epididymis and a *vas deferens* ran in the broad ligament below the tube. The uterus was covered in front, above and on the upper third of its posterior surface by peritoneum. Its greatest breadth was 37 millimetres, length 28 millimetres and thickness 20 millimetres. The myometrium was of a maximum thickness of nine millimetres, and the arrangement of its muscular fibres was that of the ordinary female uterus. Uterine arteries the thickness of woollen threads ran up on each side of it. The left Fallopian tube was 76 millimetres long, possessed fimbriae one to two millimetres in length, and was patent in its length to a probe. The removed sex gland (the left testis) lay in the ovarian position on the back of the broad ligament. Examined under the microscope it was noted to have normal testicular structure, and in its seminiferous tubules every stage of spermatogenesis up to the mature spermatozoa was seen. A similar section of the right testis, which was left behind in the abdomen, showed no sign of spermatogenesis. No trace of ovarian tissue was found anywhere, and the uterine endometrium, which was of low cylindrical epithelium, and possessed sparse and short glands penetrating into the muscle layers, showed no evidence of ovarian influence at all.

The case is in fact a true instance of inguinal herniation of the uterus in a male. Altogether, including a few less definitely masculine cases, 35 such happenings have now been reported, 33 of them having been discovered at operation and two at autopsy. Nilson feels that the condition should be capable of correct diagnosis prior to operation in a well-marked case such as his. Masculine pseudohermaphroditism is defined as a

condition wherein, in a man possessing testes and normal external male genitals, the Müllerian ducts have developed in the feminine type. The extreme degree of this development would appear to be in the recorded case in which a well-formed uterus and tubes lay between the bladder and the rectum and communicated with the prostatic urethra by a miniature vagina. That the owners of such organs are undoubtedly male and masculine is shown by the fact that many of them were married, and one at least was the father of eight children.

Treatment should aim at the retention of the male glands in their full functioning capacity and the removal of the uterus as a functionless organ. Unfortunately it is often not possible to remove the uterus without damaging the blood supply or the sperm ducts of one or other testis, particularly that one which is found down in the scrotum with it. The other one being generally intraabdominal, its spermatogenic function is usually in abeyance, and as Nilson points out it is difficult to remove the uterus and cure the hernia without thereby depriving the patient of his chance of fatherhood. It would appear, although the point is not stressed in this article, that if such should seem the probable result of the radical cure, a question of earnest and delicate judgement is imposed upon the surgeon as to whether his patient will gain or lose in the long run by having the radical cure performed.

ARTHUR E. BROWN.

TUBERCULOUS EPIDIDYMITIS.

Einar Ljunggren (Stockholm): "*Zur Diagnostik und Therapie der Nebenhoden-Tuberkulose*", *Acta Chirurgica Scandinavica*, 1940.

LJUNGREN's paper is based on a series of 68 cases occurring in patients treated in the clinic of Einar Key in Stockholm between 1917 and 1937. Tuberculous epididymitis is never a primary disease, always secondary to some focus which more thorough examination brings to light with increasing frequency. It is a striking fact that in one-half of these cases tuberculous infection of the kidney was either diagnosed simultaneously or was recognized as a precursor or developed subsequently to the appearance of the epididymitis. Wildbolz's large series confirms this statement, although most authors estimate the occurrence of renal tuberculosis as somewhat less common. Further, out of nine cases in this series in patients who died and were subjected to post-mortem examination, in only one were the kidneys found to be free from tuberculosis.

Recent cases at the Maria Hospital Clinic are being investigated for involvement of the prostate and seminal vesicles. Rectal palpation in such cases is often misleading; but urethrograms of the prostate revealed cavities in the gland in 14 of the 28 cases in which this examination was made. In the other 14 in which the urethrogram was not clearly positive, rectal palpation indicated in one-third findings accepted as typical of prostatic tuberculosis. By both methods of examination, changes probably tuberculous were demonstrated in the prostate and vesicles in 65% of cases. Surprisingly, there was only one case among them in which the infected prostate appeared to cause symptoms. In this respect the diagnosis between tuberculous and non-tuberculous prostatitis is not easy; but on the whole dilatation of the prostatic ducts is more common in non-specific prostatitis and cavity formation more usual in tuberculous infection. Difficulty in differential diagnosis between tuberculous and non-tuberculous infection in the epididymis itself is of minor importance, for, as Ljunggren points out, any infection destroys the function of the epididymis, and it is no loss to the patient to have it removed for microscopic or other examination.

In treatment, epididymectomy is the method of choice, and if the testis is found to be involved in the disease, resection of the diseased portion is also performed. In the small number of cases in which the testis is damaged beyond hope of cure, semicastration is done; this is also done in those cases in which the successful performance of epididymectomy must necessarily destroy the blood supply of the testis. Recurrences were more frequent in semicastrated patients than in those more conservatively treated. Cases requiring a second operation on the opposite side were almost all easily dealt with by epididymectomy alone, which Ljunggren takes to indicate the benefit of the earlier approach by the patient to the surgeon in the case of the second gland. Of all the testes treated in a conservative manner—74 in number—later removal of the testis was required for ten, or 13%. This figure corresponds with Nylander's figure of 15%, but is considerably higher than that usually given by most authors, which is generally in the neighbourhood of 2% to 3%. In a review of the size and apparent functional condition of the testes left after successful epididymectomy and reexamined some years later, Ljunggren is inclined to the opinion that the surgeons may have gone too far in their endeavours to limit the operation to the minor procedure and to conserve the testis, and that in some cases hemicastration would have brought more benefit to the patient.

In the late result, 25 of the 68 patients reviewed are dead, and 41 are known to be alive, 17 of these having survived the operation for more than ten years, and 12 of them being in all ways healthy. But the reader finds on reviewing the series on a five-year survival basis that 31% are dead, and the need for careful, thorough general medical treatment and hygiene for these people is evident. Actually earlier reporting and more careful after-treatment and supervision will probably have a much greater effect in reducing mortality from tuberculous epididymitis than will the choice of this or that particular operative technique.

ARTHUR E. BROWN.

SPONTANEOUS HEALING OF OSTEOCHONDRITIS DISSECANS IN THE KNEE JOINT.

Gunnar Wiberg (Stockholm): "*Spontanheilung von Osteochondritis Dissecans im Kniegelenk*", *Acta Chirurgica Scandinavica*, Volume lxxxv, 1941, page 420.

WHEN a knee joint is discovered to be affected with *osteochondritis dissecans* it has been in the past a routine procedure to operate upon it, largely owing to the feeling that something dangerous is being left in the joint if operation is not performed. This theory has, however, been controverted by Löhr's experience in collecting a series of cases in which with no operation complete healing of the disease process occurred, or in which, in spite of the presence of a detached loose body in the joint, *arthritis deformans* did not supervene. Wiberg is unable to discover any other series than this in the literature, probably because nearly every patient is operated upon when the condition is diagnosed.

At the orthopaedic clinic at the Caroliner Hospital in Stockholm it has been the practice for some years to follow a conservative line of treatment in suitable selected cases; and the patients in the series herein presented by Wiberg have been under his personal supervision since 1937. The period of observation is admittedly short, but it is sufficient to give a strong indication of the healing process. There are ten such patients, three of them affected in both knees; and of these thirteen knees only four have been operated upon, either on the grounds of a loose body present or of pain in the joint. Of the remaining nine, two were in patients above the age of twenty years, which Wiberg holds is too old for spontaneous healing to be expected; two undoubtedly progressed to spontaneous cure, and in the remaining five, though the chance of spontaneous cure would now appear to be slight, no operation has so far been undertaken. In addition to this series, three other cases have been added for the purposes of this article, one from Professor Waldenstrom and one from Dr. Nilssonne. In one of these the disease was bilateral.

A typical example of these cases may be illustrated here. The patient was a girl, aged eleven years when first seen in April, 1931. Radiographic examination of the left knee revealed a well demarcated separating portion of the articular surface of the medial condyle, about the size of a pea (Figures I and II). The girl was forbidden to partake in games, but otherwise her activities were not restricted. Further examination in November, 1932, indicated that the fragment was still demarcated. She was quite free from symptoms at this time. Radiographic examination in September, 1933, showed

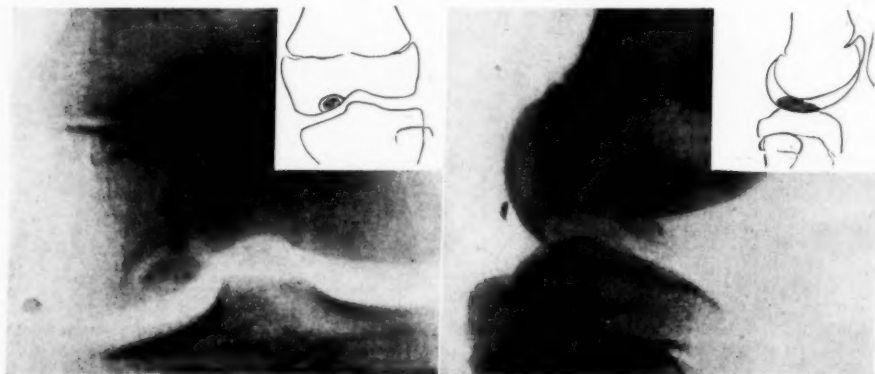


FIGURE I.

FIGURE II.

no sign of the previous fragmentation, and a final film taken in January, 1940, confirms the completeness of the healing (Figures IIIA and IIIB).

This series of six knee joints affected with *osteochondritis dissecans* in a well marked form and progressing to spontaneous and complete cure must be regarded as important from the point of view of our outlook on these cases. Bearing in mind Löhr's dictum that the radiographic findings do not necessarily correspond with the anatomical conditions present, one may hesitate to declare that these joints are completely cured. But one has also to bear in mind the fact that a joint that has healed spontaneously is a better joint than one that has been operated upon, however skilfully.



FIGURE IIIA.

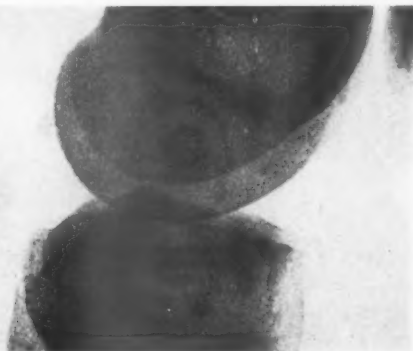


FIGURE IIIB.

The question remains as to whether it is possible to tell beforehand which joints are likely to respond to conservative treatment. Youth seems to be the deciding factor. Five of these patients were less than sixteen years old, and the other, though nineteen at her final examination, was first seen at fifteen, and was not reexamined after that until the age of nineteen. Her joint may well have been in a healing stage when first seen. In any case, it would seem that conservative treatment has much to offer to young people, if little to offer patients over twenty. It would be an ideal procedure in such cases to have X-ray examinations made every six or twelve months, to keep the process under control. Once the bony fragment becomes loose in the joint it becomes a danger, causing pain, disability, and later arthritis. And the number of such loose bodies which find a secondary attachment to render them innocuous must be extremely small.

The dangers involved in the conservative treatment of this condition are minimal, and on indication it can readily be changed to active treatment. Pain as such an indication would vary from one patient to another. Locking of the joint in patients over twenty years of age should be regarded as an absolute indication for operative treatment.

ARTHUR E. BROWN.

LATE RESULTS OF TRANSVERSE SUTURE OF THE DIVIDED URETER.

Karl Ostling (Falun): "Zur Kenntnis der Spätresultate bei Naht des querdurchtrennten Harnleiters", *Acta Chirurgica Scandinavica*, Volume lxxxiii, 1939-1940, page 74.

THE commonest indication for transverse suture of the ureter is accidental division of it during pelvic operations. The results published have not been good, and whenever possible the implantation of the upper portion into the bladder or even into the bowel has been widely preferred. Experimental evidence shows that in the ureter, as in other comparable organs in the body, complete regeneration of smooth muscle tissue is not to be expected, although the late functional results may be quite good, particularly if the precaution has been taken to drain urine off above the suture line to avoid its soiling during the process of healing.

Wildbolz, experimenting on dogs, severed the ureters just below the renal pelves, and resutured them without drainage. Serial excretion pyelograms were then taken during the following two years, and any animal in which dilatation was seen above the suture line was killed and the organs were closely examined. At the end of the two years five of the ten dogs operated on were alive and well. A few hydronephroses developed, but on the whole the results were good and permanent. Since about 1929 clinical results seem to have improved and a number of successful cases have been reported. Results at the Falun Clinic of investigations on the power of organs and

tissues to take up function again and to repair damage, seem to encourage the hope that the clinical results of transverse suture of the ureter should not be as bad as many have thought; and an actual case which is reported, offers some explanation as to why they have been viewed in an unduly gloomy light. In this case the left ureter was cut through during the difficult dissection of a left pyosalpinx. A ureteric catheter was passed up the ureter from the bladder, threaded into the upper portion and passed into the kidney. The divided ends of the ureter were sutured over the catheter. Urine flowed freely through the catheter, which was left in position for a week and then removed. Two weeks later the bladder was examined by cystoscope. The left ureteric orifice appeared to be normal, but a catheter passed up it was obstructed at about nine centimetres from the orifice and could not be passed further.

Two months later the patient suffered from an acute bilateral pyelitis. On cystoscopic examination the same obstruction was found as before in the lower part of the left ureter, and turbid urine was seen flowing from that orifice. Contrast fluid injected into the catheter would not pass up the ureter beyond the obstruction. The symptoms abated and disappeared in a few days. The advisability of operating on the ureter was considered, but it was decided to defer action pending further observation.

Eight years later there occurred an opportunity for reexamining this patient, and it was found that she has been entirely free from all symptoms in the interval, while excretion urography revealed an entirely normal appearance of both renal pelves and only slight dilatation of the lower part of the left ureter. At the same time, at the site of the suture line there was a definite contraction and attempts to pass a catheter beyond it and to inject contrast fluid past it both failed, exactly as they had failed eight years before. Ostling considers it evident that some sort of one-way valve had been formed.

The combination of such good clinical results with unsatisfactory local anatomical findings is interesting, and suggests that prior to the introduction of intravenous contrast substances, undue weight was given to anatomical abnormalities in considering prognosis. Marion published a review of 84 cases in 1929 in which he laid down as a standard of cure that the affected kidney must be catheterized, and urine from it analysed and found normal before a final opinion was passed on the result. Needless to say, this was not possible in many of his cases, and the absence of excretion pyelography as a method of examination prevented him from correcting the bad impression gained. There may indeed be some diminution of the excretory function in these cases; but this is certainly not sufficient to make the surgeon's choice of procedure turn in the direction of such radical procedures as nephrectomy or implantation of the ureter into the bowel. It is in fact likely that late reexamination by excretion pyelography in many of the cases previously reported in the literature as poor results would put the procedure of end-to-end suture of the divided ureter in a much more favourable light.

ARTHUR E. BROWN.

Review.

Clinical Roentgenology of Pregnancy. By WILLIAM SNOW, M.D.; 1942. Springfield: Charles C. Thomas. London: Baillière, Tindall and Cox. Super royal 8vo, pp. 192. with 119 illustrations and 11 charts. Price: \$4.50 net.

THOUGH X-ray pelvimetry has been practised for the past two decades, the technical difficulties, reinforced by the unenthusiastic attitude of obstetricians, have militated against its general employment. Many obstetricians of sound judgement have adopted the attitude that where pelvic contraction is gross, thus requiring Caesarean section, it can be sufficiently well recognized by clinical methods, and that when the degree of contraction is slight or doubtful, a trial of labour can properly be undertaken. With the several factors other than pelvic diameters entering into normal or difficult delivery, clinicians might be excused for suggesting that radiological ambition was overleaping itself in an attempt to equate the biological act of parturition with units of the inflexible and inanimate metric system. However, during the past ten years or so, owing to the strong advocacy of such authorities as Herbert Thoms, Professor of Obstetrics at Yale, Caldwell and Moloy of New York, Munro Kerr of Glasgow, and Chassar Moir of Oxford, X-ray pelvimetry is today far from being neglected as an antenatal investigation.

This monograph by William Snow, Director of Radiology, Bronx Hospital, Röntgenologist-in-Charge, Harlem Hospital, New York, accepts the viewpoint that X-ray pelvimetry must become more general, and is directed mainly to the contention that X-ray pelvimetry can be so simplified that the intimidation of previous technical complexities should no longer exist. The short work is divided into two parts, the first dealing with the maternal pelvis and the foetus, and the second with the soft structures of pregnancy.

Snow uses only two films—one antero-posterior and the other a true lateral (centred over the middle of the pelvic inlet)—for his pelvimetry and cephalometry, and claims that with the use of a slide-rule and calculator which he has devised, the diameters of the pelvic inlet, mid-pelvis, outlet, perimeter and average diameter of the fetal skull can easily be computed; the measurement of the maternal diameters is said to be correct to within five millimetres; from the perimeter and average diameters of the skull the fetal weight and age can be estimated. It might have been stressed, however, that by any method cephalometry is much less reliable than pelvimetry. In discussing those non-pathological variations in the female pelvis due to racial, sexual and hereditary factors, and how delivery may be influenced by such variations, the author adopts the well-recognized Caldwell and Moley classification into anthropoid, gynecoid, platypelloid, android and asymmetrical types. Only X-ray pelvimetry permits of the recognition of these types, for external pelvimetry or bodily habitus gives little clue to their presence.

In the forty pages of the second section of the book devoted to radiological visualization of the soft tissues in pregnancy, the author discusses the demonstration of the placental site, *placenta previa*, premature separation of the placenta, hydramnios, tumours complicating pregnancy and extrauterine gestation. He wisely discards that method of locating the placenta *in utero* which depends on injection of radio-opaque material into the amniotic sac, and has found that the injection into the bladder of air, rather than sodium iodide, is preferable in the X-ray diagnosis of *placenta previa*. In this condition there is, on the film, an increased width of the soft-tissue shadow corresponding to the lower uterine segment, but it should be recognized that there are pitfalls in the diagnosis of *placenta previa* by such methods, and the radiologist of experience will keep very close to his obstetrical colleague while making a report. The same caution is applicable in other "soft-tissue" diagnoses, in which no extraneous contrast material is utilized, for the differences in radiographic density (on which the diagnosis depends) between the maternal abdominal wall, uterine wall, placenta and amniotic fluid is very slight. However, the author has done a service in counselling the radiologist to pay closer attention than hitherto to the soft-tissue shadows: in the past, scrutiny has too often been focused only on the fetal skeleton and the maternal bones.

Dr. Snow has compiled a stimulating monograph which will repay a reading both by the radiologist and the obstetrical teacher; but in these days of austere living, the price (\$4.50) will probably result in its being found more often in the reference than in the personal library. As usual, the publisher, Charles C. Thomas of Springfield, Illinois, has done his work beyond cavi.

Proceedings of the Royal Australasian College of Surgeons.

THE HYDATID REGISTRY.

THE following is the report of the Hydatid Registry of the Royal Australasian College of Surgeons for the twelve months ended December 31, 1941, submitted by the Registrar-in-Chief, Sir Louis Barnett:

Owing mainly to war disorganization in civilian medical practice, the number of new hydatid records received during the year fell to very meagre dimensions.

The records now filed, indexed, summarized and stored in the Gordon Craig Library of the Royal Australasian College of Surgeons total 1,587—an increase of only 35 over last year's figure.

Our Secretary, Mr. H. G. Wheeler, and our Librarian, Miss N. Andrew, continue to give valuable service in the collection and storage of the records, and to them and to all my surgical and medical colleagues who have been able and willing to help in the work of the registry I proffer personally and on behalf of the College very sincere thanks.

In addition to the cases of peritoneal invasion, a considerable number of the lung cases and a few others also harboured cysts in the liver, so that the actual total of liver locations is much higher than the number quoted in the accompanying table. A complete count and comparison of liver and lung invasions give the following result:

Liver invasions—Australian cases, 574; New Zealand cases, 515: a total of 1,089 out of 1,587 records, or 68.6%.

Lung invasions—Australian cases, 180; New Zealand cases, 206: a total of 386 out of 1,587 records, or 24.3%.

Compared with the figures published in Professor Dew's book ("Hydatid Disease", 1928) and in foreign literature, this total of 24.3% for lung invasion appears remarkably

Classification of the Cases according to the Part of the Body Chiefly Affected.

Situation.	Indexed Records.		Total Records.	Indexed Deaths.		Total Deaths.
	Australia.	New Zealand.		Australia.	New Zealand.	
Liver	484	429	913	70	61	131
Peritoneal ¹ .. .	70	55	125	7	9	16
Lungs .. .	157	189	346	11	19	30
Muscles and fascia .. .	35	42	77	1	1	2
Bone—						
Spine .. .	16	5	21	2	1	3
Other bones .. .	13	10	23	3	1	4
Kidney .. .	14	24	38	2	5	7
Spleen .. .	14	4	18	2	1	3
Brain .. .	6	8	14	1	4	5
Heart .. .	2	1	3	—	1	1
Thyroid .. .	—	2	2	—	—	—
Parotid .. .	1	—	1	—	—	—
Prostate .. .	—	1	1	—	—	—
Pancreas .. .	—	1	1	—	—	—
Breast .. .	1	2	3	—	—	—
Orbit ² .. .	1	—	1	—	—	—
Totals .. .	814	773	1,587	99	103	202

¹ Entitled in index as "Multiple Abdominal and Pelvic" almost all secondary to leaking liver cysts.

² Indexed under "Muscles and Fascia".

high, and it is possible that in Australia and New Zealand there is some factor at work that favours pulmonary location. The localization of hydatid cysts in this or that portion of the body is no doubt largely influenced by the anatomical arrangement of the blood vessels; but this is not the whole story. Based on the registry records and on a study of the literature dealing with hydatid localization, I have prepared a paper on this subject and have submitted it for publication in our journal. This article may appear in a future issue, but at present it is held over for revision at the request of the Editorial Committee.

In the issue of our journal for July, 1941, an interesting and instructive article on hydatid disease of the kidney was contributed by Mr. E. R. Reay, F.R.A.C.S., of Christchurch, and the author expressed grateful appreciation of the data he was able to secure from the registry.

L. E. BARNETT,
Registrar-in-Chief.

ANNUAL REPORT OF THE COUNCIL.

THE Council of the College takes pleasure in submitting to Fellows the following statement recording College activities during the last twelve months.

Meetings of the Executive Committee.

The Executive Committee has met on ten occasions, the attendances being as follows:

Sir Hugh Devine	9	A. L. Kenny	9
Sir Alan Newton (on military service)	4	Victor Hurley (on Air Force service)	6
Balcombe Quick	7	G. R. A. Syme	4

Copies of the minutes recording the proceedings at these meetings have been mailed to all members of the Council.

Meetings of the Council.

Two meetings of the Council of the College have been held since the fourteenth annual general meeting. The attendances were as follows:

E. D. Ahern	0	George Bell	0
Sir Alan Newton	2	H. R. Dew	2
H. R. G. Poate	1	Victor Hurley	2
Balcombe Quick	2	A. L. Kenny	2
Sir Hugh Devine	2	Sir Henry Newland	1
F. Gordon Bell	0	Sir Robert Wade	0

Fellows of the College.

The number of Fellows at the date of this report is as follows:

Honorary Fellows	17
Overseas Fellows	12
Australian Fellows—	
New South Wales	184
Queensland	47
South Australia	48
Tasmania	13
Victoria	182
Western Australia	26
	— 500
New Zealand Fellows	133
	662

Fellows on Service.

The following is a summary of the Fellows of the College on full-time duty in the Services:

Army—

Australia	104
New Zealand	30
	— 134

Navy—

Australia	4
New Zealand	2
	— 6

Air Force—

Australia	5
	145

Deaths of Fellows.

It is with regret that the Council reports the deaths of the following Fellows:

New South Wales: W. E. Kay (died on active service), William Chisholm, A. P. Gillespie, W. Perry, F. Antill Pockley, H. Z. Throsby.

New Zealand: F. S. Batchelor, W. C. McCaw, Kenneth MacKenzie, A. C. Purchas, P. T. Putnam, James Young.

Queensland: Hon. C. F. Marks.

Victoria: S. A. Ewing, W. Kent Hughes, R. H. Morrison, Zelman Schwartz (died on active service).

Gordon Craig Library.

The Gordon Craig Library has continued to expand and develop during the past twelve months. A number of valuable gifts have been received, and a policy of purchasing selected new books has been carried out. The Council desires to place on record its gratitude to the following donors: Sir James Elliott, E. Gutteridge, G. H. Hogg, Thomas King, Major F. H. Moran, Sir Henry Newland, H. R. G. Poate, Mr. R. Sholl, R. Scot Skirving, G. R. A. Syme.

Journal.

Beginning with the July, 1941, issue, THE AUSTRALIAN AND NEW ZEALAND JOURNAL OF SURGERY appeared in a new form. This was necessary in order to fulfil the obligations of the College under the paper rationing regulations and also to conserve stocks of British art paper. Although the College was granted an exemption from the provisions of the paper rationing regulations, it is in honour bound to effect every economy possible in the use of paper.

The Council desires to record its gratitude to Colonel W. A. Hailes for his untiring efforts in obtaining papers from surgeons on active service for publication in the journal. Colonel Hailes has done a great deal to stimulate the interest of these men in the work of the journal. Practically the whole of the January, 1942, issue was devoted to papers dealing with war work, and it is considered that the next few issues of the journal will include many papers received from men on active service.

Meetings Arranged by the State and Dominion Committees.

Some States have experienced, and are experiencing, difficulties in arranging their usual programme of scientific meetings. However, during the last twelve months the following meetings have been organized:

New Zealand: Annual meeting, Christchurch, August 30, 1941.

Queensland: Clinical meeting, Brisbane, May 1, 1941. Annual meeting, Brisbane, June 4 and 5, 1941. Clinical meeting, Brisbane, October 9, 1941. Evening lecture, Brisbane, December 5, 1941.

Ryan Scholarships.

The examinations for the Michael and J. P. Ryan Scholarships in Surgery were held in September, 1941. The results were as follows: Michael Ryan Scholarship in Surgery, awarded to J. M. McCracken; J. P. Ryan Scholarship in Surgery, awarded to G. S. Christie (*proxime accessit*, J. H. McConchie).

The Council desires to record its gratitude to the examiners, Mr. F. J. Colahan and Mr. G. R. A. Syme.

Plan for a National Health and Medical Service.

The Executive Committee gave consideration to the draft plan for a national health and medical service, which was recently approved by the National Health and Medical Research Council. In doing so, the Executive Committee did not decide the principle as to whether the College should enter directly into medico-political discussions of this nature, but made it clear that this matter was one for the Council to decide. The draft plan was referred to a subcommittee of the Executive Committee for detailed consideration and advice. The subcommittee was given power to confer with representatives of other bodies, but had no power to commit either the Executive Committee or the Council. The deliberations of the subcommittee ceased when it was learned that the Federal Minister for Health had stated that no attempt would be made to introduce the plan until after the cessation of hostilities, and further that the views of the medical profession would be sought before an attempt was made to implement the plan. This matter, therefore, so far as the College is concerned, now remains in abeyance.

Australian Red Cross Society.

The Australian Red Cross Society sought permission from the College to erect a temporary wartime hut close to the College-building in the College gardens. The hut is to house the staff of the society engaged in its department devoted to inquiries for wounded, missing and prisoners of war. The College, after consideration, decided to grant this request on terms and conditions which protect the interests of the College. An agreement has been entered into between the College and the society.

Destruction of the Museum of the Royal College of Surgeons of England.

The President of the Royal College of Surgeons of England, Sir Alfred Webb-Johnson, enlisted the cooperation of the Royal Australasian College of Surgeons in the reestablishment of the museum of the Royal College of Surgeons of England which was destroyed by enemy action. The Council is anxious to assist the Royal College of Surgeons of England, and the Secretary has communicated with every public hospital in Australasia, with the Australian Institute of Anatomy, and with Sir Louis Barnett, in an endeavour to have rare and interesting specimens mounted and held until after the cessation of hostilities, so that they might be presented to the Royal College of Surgeons of England.

The following institutions have advised that they are willing to cooperate in connection with this work: the Australian Institute of Anatomy; Royal Prince Alfred Hospital, Sydney; Women's Hospital, Melbourne; Brisbane General Hospital; Saint Vincent's Hospital, Melbourne; Royal Alexandra Hospital for Children, Sydney; Christchurch Hospital, Christchurch; Alfred Hospital, Melbourne.

Brisbane Meeting, 1942.

The Council intended to arrange a general meeting in Brisbane during 1942. It was with great regret, however, that, after consulting the President and the Chairman of the Queensland State Committee, it was necessary to decide that, in view of the international situation, it would be unwise to arrange a general meeting in Brisbane during this year. The meeting was, therefore, abandoned.

Balance Sheets and Accounts.

Copies of the balance sheets of the College will be handed to Fellows present at this meeting. The detailed accounts are available at the meeting for inspection by Fellows. Any information which Fellows might desire concerning the accounts will be supplied on request.

Election of Council.

Six nominations were received to fill the six vacancies on the Council. All the retiring members of the Council were renominated.

H. G. WHEELER,
Secretary.

COUNCIL MEETING.

THE Council met on Saturday, April 18, 1942, and the following matters arising out of the meeting are published for the information of Fellows.

Election of Council.

Six nominations were received for the six vacancies on the Council. All the retiring members of the Council were renominated and declared reelected. The members of the Council reelected are as follows: E. D. Ahern, George Bell, Victor Hurley, A. L. Kenny, Sir Henry Newland, Balcombe Quick.

Appointment of Executive Committee.

The following members of the Council were appointed an Executive Committee: Sir Hugh Devine (Chairman), Sir Alan Newton, T. E. Victor Hurley, A. L. Kenny, Balcombe Quick.

Appointment of State and Dominion Committees.

The following appointments were made:

New South Wales: J. C. Storey (as deputy for A. J. Aspinall), V. M. Coppleson, T. M. Furber (as deputy for F. Brown Craig), B. T. Edye, E. M. Fisher (as deputy for I. Douglas Miller), J. W. S. Laidley, T. W. Lipscomb (as deputy for A. M. McIntosh).

Queensland: Hedley J. Brown, A. E. Lee, H. S. McLelland, J. J. Power, A. D. D. Pye (as deputy for J. C. Hemsley), Neville G. Sutton.

South Australia: R. M. Glynn, I. B. Jose, L. C. E. Lindon, R. E. Magarey (as deputy for B. H. Swift), P. S. Messent, L. A. Wilson.

Tasmania: F. W. Fay, B. Hiller (as deputy for J. Bruce Hamilton), H. W. Sweetnam (as deputy for D. W. L. Parker).

Victoria: A. Fay Maclure, J. Newman Morris, Henry Searby, C. Gordon Shaw, John H. Shaw, G. R. A. Syme (as deputy for W. A. Hailes), B. T. Zwar.

Western Australia: J. P. Ainslie (as deputy for F. J. Clark), H. B. Gill, D. D. Paton.

New Zealand: P. S. Foster, J. A. Jenkins, Frank Macky, J. Leslie Will, David Whyte, D. S. Wylie.

Admission of New Fellows.

The following new Fellows were admitted by the Council:

General Surgery.

New South Wales: Thomas Edward Wilson.

Tasmania: John Bertram Gilchrist Muir.

